A COMPETITIVE STRATEGY MODEL FOR HIGHWAY CONSTRUCTION PROPOSALS

by

LARRY RAY JOHNSON

Bachelor of Ceramic Engineering
Georgia Institute of Technology
Atlanta, Georgia
1958

Bachelor of Industrial Engineering
Georgia Institute of Technology
Atlanta, Georgia
1960

Master of Science
Georgia Institute of Technology
Atlanta, Georgia
1962

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Thesis Approved:

M. P. Terrell
Thesis Adviser

G. T. Stevens, Jr.

W. S. Hanneman

Dale E. Bae

E. J. Ferguson

J. D. Durham
Dean of the Graduate College

PREFACE

A contractor bidding on highway construction projects faces two conflicting objectives: first to be the low bidder so as to win the project, and second, to earn as high a profit as possible. The conflict is apparent because the higher the contractor bids, the more profit is realized, but the less likely he is of being the low bidder. The submitted bid will be a compromise between these two objectives, and will be based both on the contractor's cost experience with similar projects and his knowledge of the industrial environment at that time.

Models are developed in this dissertation to aid the contractor in making his decisions when bidding for paving projects. These models involve the development of a distribution of low bids which can be expected for a specific project, based on the required work items. From this distribution and the estimated cost of the project, the optimum bid, maximizing the expected profit, is determined.

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FORMULATION OF THE PROBLEM

Introduction

Bidding for highway paving projects requires the contractor to face conflicting objectives: bidding high to achieve a high profit level and low to increase the likelihood of winning the project. Several models have been developed to aid him in determining the optimum bid, the one which maximizes the expected profit, however all were found deficient when applied to the highway construction industry.

To calculate the optimum bid, it is necessary to estimate the probability of being the low bidder for a project as a function of the amount bid, P(x). Ideally, this estimate should be (1) independent of the estimate of the project cost, and (2) independent of the number or identity of the competing bidders. It is hypothesized that P(x) can be estimated so as to satisfy these criteria, by first estimating the bid of the lowest competitor by means of a regression analysis. A probability distribution can be determined for each regression estimate from which P(x) can be evaluated.

The expected profit is the amount of profit included

in a bid of size x times P(x), the probability that a bid of that size will be the lowest. By varying the amount bid, the value which maximizes the expected profit can be identified, and taken to be the optimum bid.

Background

Bidding to perform a service or to purchase a property is not an uncommon practice in most industries. In the construction industry, bids are submitted for the purpose of constructing various types of structures. In the defense industries, companies bid against each other for the right to investigate the feasibility of a new weapon system, or to modify an existing one. Small individually owned businesses are often asked to quote a price for a given quantity of a competitive product. In fact, the pricing of any product or service can be envisioned as a form of bidding for the consumers' dollars.

Because the field of competitive bidding is so broad, this study is limited to closed bidding, as opposed to open, or auction, bidding. In the latter case, the competitors bid openly against each other until none are willing to increase their bid value any further. In closed bidding, the competitors independently determine the price which they are willing to pay for a property or for which they are willing to perform a service. By independently it is meant that there is no collusion either between the various competitors or between any competitor and the owner. Each

competitor is allowed only one bid, and it must be submitted before a specified time on a specified day. On that day and at that time, all bids are read and the competitor submitting the lowest bid for a service, or the highest bid for a property is declared the winner. This type of bidding procedure is typical of the highway construction industry and this study is limited to that industry.

Competitive bidding in the highway construction industry has two conflicting objectives: first, to be the low bidder so as to win the project, and second, to earn as high a profit as possible. A conflict is apparent because the higher a contractor bids for a project, the more profit he makes, but the less likely he is of being the low bidder. The ideal bid for the successful contractor would be for it to be one cent less than the bid of the second low bidder. The difference in the bids of the two lowest bidders is called the spread and is considered as money lost, or as "money left on the table".

Because of the two conflicting objectives, competitive bidding is described by Edelman (1) as both an art and a science. It is an art because of the number of factors which are known or partially known which cannot be manipulated in a model, but which should be considered when setting the final bid value. These are the intangibles and include such factors as: the identity of the contractors' competitors and how they have bid in the past, how desperately he or they need the additional work to maintain

the organization at its current level, or the evaluation of future work opportunities if the current project is lost. These and other considerations will tend to raise or lower the bid depending on the "feelings" of the contractor concerning the present and future industrial environment.

There are a great number of factors which can be quantitatively treated and these have tended to put the bidding procedure on a more scientific basis. The use of the critical path methods and statistical procedures have greatly reduced the number of "seat of the pants" decisions which were required in the preparation of the bid. Accurate accounts of the costs of previous projects, classified in such a manner as to be useful in preparing future bids, a reasonable knowledge of equipment capabilities relative to the project in question, correct allocation of overhead charges, and records of the results of previous bids of both the contractor and his competitors, provide the basis on which a competitive bid may be made.

When all numbers have been calculated and all intangibles considered, unknown elements still exist for which no consideration can be given, or about which incorrect assumptions have been made. Thus, the final bid value is the result of an intuitive decision, but perhaps is one based on a more scientific foundation. A number of bidding models have been developed to aid the decision maker with his problem. Generally, these models assume that the project costs have been estimated and that the contractor

is deciding how much profit he should add to the cost so that he has a good chance of being the low bidder and also that he makes a "fair" profit. These bidding models are not meant to replace the decision process of the contractor, but to complement it. The final bid will always remain the responsibility of one man, the one making the final decision of its amount.

Bidding Models

Of the bidding models which have been developed, three will be reviewed in detail because of their separate approaches to the problem. The first requires extensive knowledge of the bidding pattern of the contractors' competitors. The second permits the contractor to optimize his bid by knowing the average spread between the low and second low bidders. The third requires introspection of the contractors' own bidding pattern. Other bidding models pertinent to the highway construction industry are either obviously outgrowths of these three, and thus do not add significantly to the "state of the art", or depend on known special relationships between the bidder and owner. Terrell and Johnson (2) found that this latter case is not permitted since most state laws require the project to be let to the lowest qualified and responsible bidder. It is in only the rarest instance that the lowest qualified and responsible bidder is not also the lowest bidder because of the pre-qualification requirements of the state highway departments

and/or the bonding companies.

Friedman's Competitor Model

The most commonly used criteria in setting a bid value is that of maximizing the total expected profit, E(x), from the bid. This is a function of the probability that a bid value of x, P(x), will be the lowest and win the project, and the profit markup for that project. If C is the expected cost of the project to the contractor, then

$$E(x) = P(x) \cdot [x - C] \tag{1.1}$$

The difficulty in determining the expected profit from a bid, E(x), lies in determining P(x), the probability of being the low bidder. If it is assumed that for every previous project for which the contractor has made a cost estimate, the results of the bidding of all his competitors are known (as is the case in the highway construction industry), then Friedman (3) suggests that this difficulty might be overcome by studying the distribution of the ratios of the competitors bids, say x_r, x_s, x_t, to his cost estimate, C. If there are enough previous projects on which competitors R, S, T, etc., have bid, then x_r/C, x_s/C, x_t/C, etc., will emerge as distinct distributions indicating the competitors' separate bidding behavior. The distributions of three hypothetical competitors is shown in Figure 1.

The probability that the bid of competitor R, x_r, is greater than the bid of x is the same as the probability of

x_r/C being greater than x/C since C is a constant for a given project. This probability is interpreted as the probability of underbidding competitor R with a given bid of x, and is represented by the shaded portion of the curve for competitor R.

$$P(x_r > x) = P(x_r/C > x/C) \tag{1.2}$$

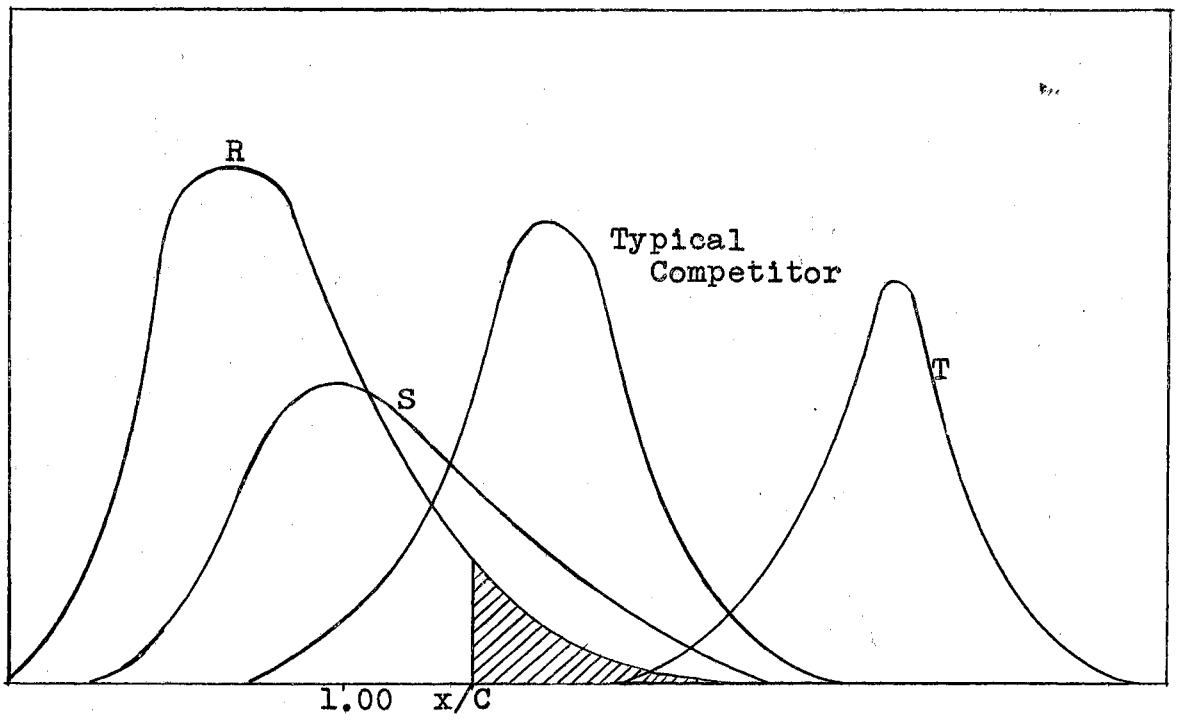

Figure 1. Bidding Patterns of Competitors

The probability of being the lowest bidder against three known competitors, R, S, T, is simply the product of the probabilities of underbidding each separately.

$$P(x) = P(x_r > x) \cdot P(x_s > x) \cdot P(x_t > x) \qquad (1.3)$$

The problem becomes more complex if either the bidding characteristics of the individual competitors is not known and/or the number of bidders is not known. In the former case, Friedman suggests developing a curve representing the "typical" competitor. Thus, the probability of beating one typical competitor is

$$P(x_{typ} > x) = P(x_{typ}/C > x/C) \qquad (1.4)$$

The probability of beating k typical competitors is then

$$P(x) = [P(x_{typ} > x)]^k \qquad (1.5)$$

Once the distribution of the typical competitor has been determined, the problem shifts to that of finding the value of k, the number of competitors, if unknown. Friedman suggests considering past experience in the industry and in particular, two avenues of attack. First, the number of competitors may have a Poisson distribution. If θ is the average number of competitors, then

$$g(k) = \theta^k e^{-\theta}/k! \qquad (1.6)$$

The probability of winning P(x) would require summing over all possible number of competitors.

$$P(x) = \sum_{k=0}^{\infty} g(k)[P(x_{typ} > x)]^k \qquad (1.7)$$

Equation (1.7) may be simplified to

$$P(x) = \exp[-\theta + \theta \cdot P(x_{typ} > x)] \qquad (1.8)$$

Second, experience in the industry may indicate that the number of competitors for a project might be correlated to the project size, that is, the larger the project, the more contractors trying to win it. If this were true, then the average number of competitors could be estimated from a regression equation.

Once the probability of winning the project P(x) has been determined, then the value of the expected profit, E(x), is easily determined from Equation (1.1) as is the value of the optimal bid. Generally, the expected profit will be as shown in Figure 2.

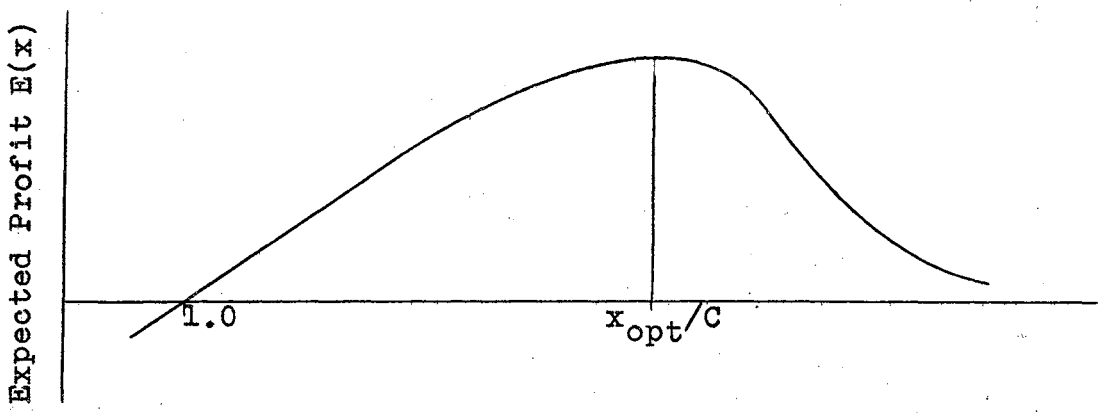

Figure 2. Expected Profit vs Amount Bid

Critique The major difficulty with Friedman's model when applied to the highway construction industry is that

it is unlikely that a contractor will be able to build up a sufficient volume of statistics on each of his competitors to establish their separate bidding patterns. This conjecture was tested by counting the number of times each possible pair of contractors, bidding in 1964, bid against each other. During that year, 136 contractors bid in 286 projects. A total of 1620 bids were submitted. The results of this count are summarized in Figure 3. The number of pairs of contractors which did not bid against each other was not counted because these contractors may not be competitors. For example, one contractor may specialize in landscaping while the other specializes in bridge construction. In this case, it would be unnecessary for one to build up a file on the other. During 1964, 80% of the contractors bidding against each other did so less than five times. For 90% of them, it was less than eight times, and for 95%, it was less than eleven times. Thus, if just the contractors bidding in 1964 were to continue bidding, it would take many years for the bidding behaviors to be established, and it is unlikely that a pattern would be stable over that length of time. With additional competitors each year, the task would be extremely difficult.

If the problem is approached by combining the information into a single distribution, then all information concerning the individual bidding patterns is lost. Indeed, Gates (4) when discussing a model similar to that proposed by Friedman came to the following conclusions based on his

experience in the highway construction industry.

LAW: THE PROBABILITY OF AN IDEALLY COMPETITIVE CONTRACTOR WINNING OVER ONE "TYPICAL" COMPETITOR TENDS TO BE 0.5.

CORROLLARY: THE AVERAGE PROFIT MARKUP TENDS TO THE VALUE THAT WILL ASSURE EACH CONTRACTOR OF GETTING HIS "SHARE OF THE WORK".

Gates' conclusion is lent credibility by the fact that new contractors are always entering the competition. With no information, it is reasonable to guess that the probability of beating them is 0.5.

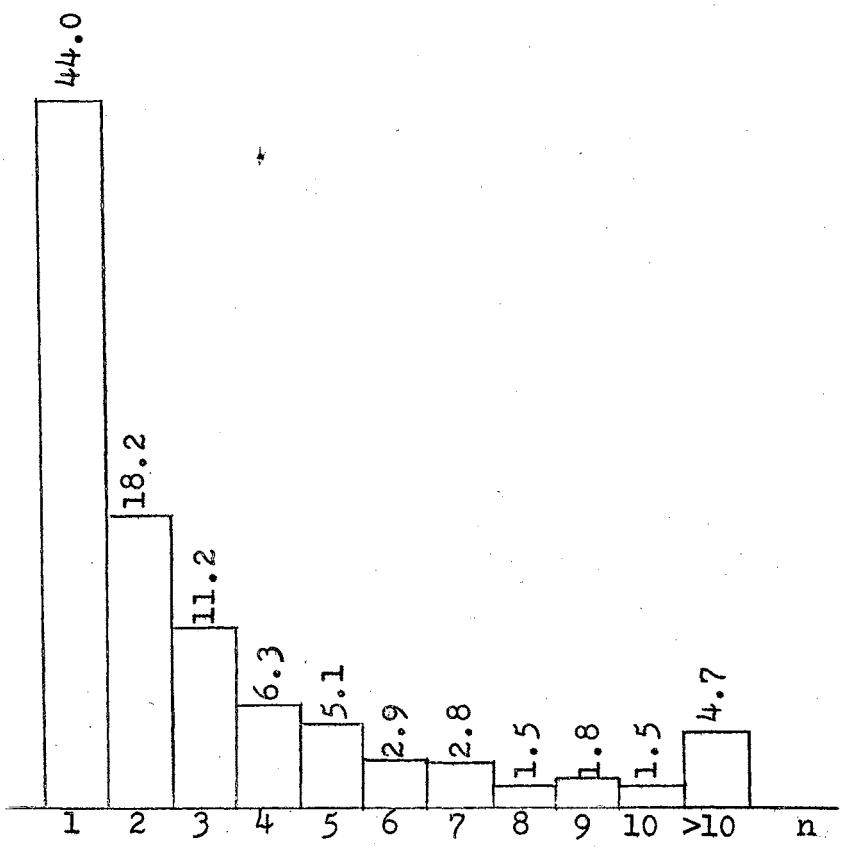

Figure 3. Percent of Contractors Bidding Against Each other n times

The Least Spread Theory

Gates (5) studied the bidding results of 381 projects let in the New England area during the period 1957 to 1959. For each project, the spread between the two lowest bids was determined and converted to a percentage of the low bid.

$$M = [(L-S)/L] \cdot 100\% \tag{1.9}$$

where

L = the low bid in dollars

S = the second low bid in dollars

M = the percentage spread rounded to the nearest percentage point.

Each percentage, M, was placed in one of nine classes, depending on the size of the low bid. The classes were defined to cover a range from \$0 to \$8,000,000 with limits approximately following a geometric progression. The geometric mean of the percentages for each class was plotted against the geometric mean of the contract sizes from the corresponding class on log-log paper, and resulted in a reasonably straight line. A line was fitted to the points by the method of least squares: one point was not included in the calculations because it was not consistent with the other values. The results of the calculations were

$$\hat{M} = 108C^{-0.266} \tag{1.10}$$

or

$$\hat{D} = 1.08C^{0.734} \tag{1.11}$$

where

$\hat{M}$ = the computed average percent spread

C = the contract size in dollars

$\hat{D}$ = the computed average spread in dollars

A scattergraph was constructed on log-log paper, plotting the spread, in dollars, against the low bid for each of the original projects plus twenty additional projects which became available. Families of curves were drawn parallel to Equation (1.11) such that various percentages of the plotted points were above the lines as is shown in Figure 4.

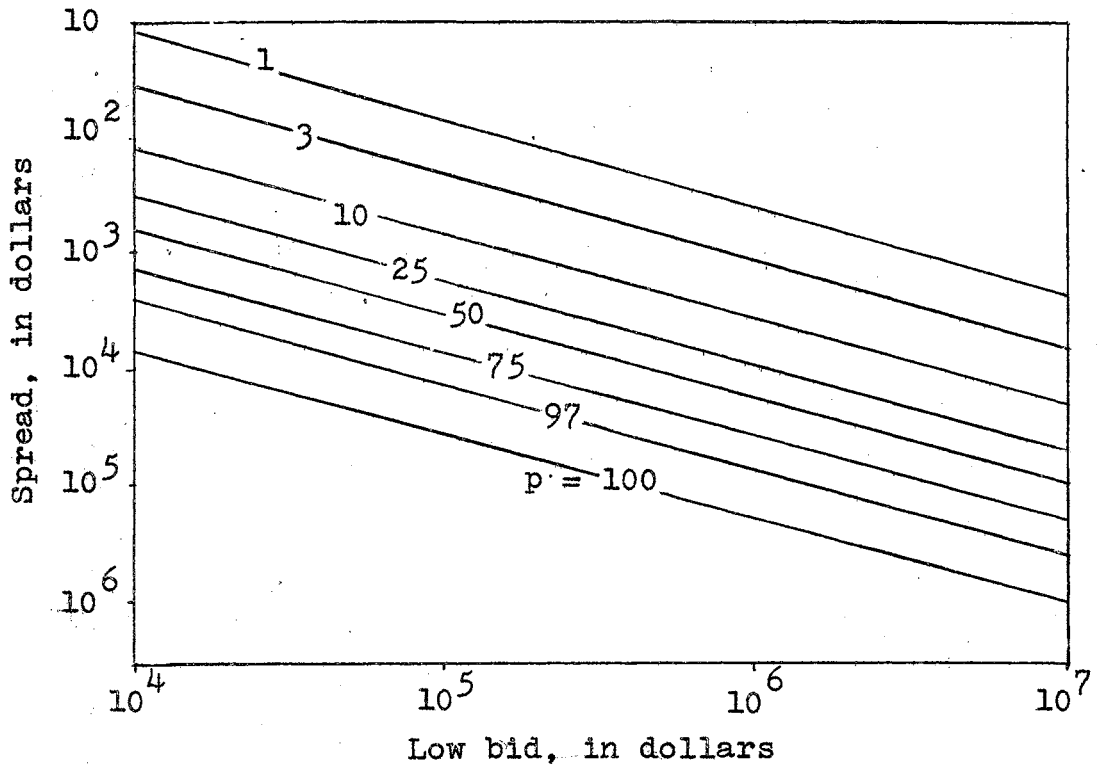

Figure 4. Number of Chances Out of 100 of a Spread Equal or Less than D Occurring.

According to Gates, the contractor may now optimize his bid by progressively adding additional dollar increments to the original bid, which already includes an unstated amount of profit. The problem must be viewed as follows:

> If you submit your completed bid without raising it, then you are 100% certain (relatively) of being the low bidder. If you increase your completed bid at the last minute by P' dollars you are now $(p)\cdot(100\%)$ certain (relatively) of being the low bidder. In the former case you stand to make P dollars profit. In the latter case, if you are successful, you stand to make $P + P'$ dollars. The expectation value in the former case is 1.00P; in the latter case it is $(p)\cdot(P + P')$. Once again, the problem is to maximize the expectation value.

The value of (p), the probability of remaining the low bidder with a profit of $(P + P')$ dollars, is found by entering the graph, Figure 4, at the original bid value (with profit included) on the abscissa and finding the (p) corresponding to the proposed increase on the ordinate.

Gates points out that in a certain region of his chart, the amount added to a bid is approximately proportional to the probability of remaining the low bidder. Using this relationship, he derives a general expression which will calculate directly the optimum amount to be added to the bid based on the amount of profit included in the original bid. If D_m is the median spread in dollars for a given size contract, found from Figure 4, then

$$P'_{opt} = D_m - P/2 \qquad (1.12)$$

Critique The usefulness of this technique is limited by the assumption that the contractor using it is the low bidder. This is a dangerous assumption even when the project is bid at or below cost. Presumably, the contractor knows how much profit he may include in his original bid and remain the low bidder. However, if this were the case, there would be no need to use the model at all.

A contractor may reason that if he bid the project at cost, he would be, in fact, the low bidder. His problem, then, lies in determining the amount of profit P to add to his bid so that he remains the low bidder. Equation (1.12) was derived to circumvent this problem by basing the incremental amount added on the profit already included (a "fair" amount by the contractor's standards). However, the results of Equation (1.12) can be unrealistic. For example, consider two contractors estimating the cost of a project. The first estimates it to cost $93,000 and adds $7,000 profit (7.3%) to bring his bid to $100,000. The second estimates it to be $100,000 and decides to bid at cost (0% profit) since he needs the additional work. Both contractors use Equation (1.12) to optimize their respective bids; in either case, D_m = $3,500. The first finds his profit remains at 7.3%

$$P = \$3,500 - 1/2(\$7,000) = \$0$$

The second is able to add 3 1/2% profit to his bid

$$P = \$3,500 - 1/2(0) = \$3,500$$

It is difficult to understand how a $7000 increase in the estimated cost of the project could realistically cause the optimal profit to be reduced by over 50%.

It may be Gates' intent that the contractor should automatically utilize this technique so that, in the event that the contractor is the low bidder, his expected profit is optimized. No help, however, is given in fixing the amount of profit to include in the original bid. If a technique could be devised to optimize the overall profit in the initial bid (as does Friedman's), then, this procedure would be unnecessary.

The Introspection Approach

In this approach, Gates (4) assumes that there are two or more competitors for every project, but the only bid values of interest are those of the contractor contemplating using this model and his lowest competitor. The latter will either be the low bidder or the second low bidder in the event that the contractor was himself the low bidder.

For every project for which a bid was submitted by the contractor, the percent difference between his and that of his lowest competitor is computed and ordered by magnitude.

$$D = [(x_c - x)/x] \cdot 100\% \qquad (1.13)$$

where

x = the contractors bid in dollars

x_c = the bid of his lowest competitor in dollars

D = the percent of the contractors bid by which the two differ.

The quantity D is interpreted as the percent the contractor should have lowered his bid in order to have been the low bidder. A negative D indicates he could have raised it by that amount and remained the low bidder.

By ordering the values of D, the across-the-board percent bid reduction necessary to yield a given long-term percent success in bidding becomes apparent. Gates presents a set of values of D taken from the records of an unidentified New England contractor; these values are summarized in Table I.

The long-term winning percentage, p, for the contractor is computed as follows:

$$p = (t/T) \cdot 100\% \qquad (1.14)$$

where

t = an Order No. from Table 1

T = the largest Order No. in Table I

For example, if the contractor desires to know by how much he should reduce his future bids in order to win 50% of the projects, he must first compute t.

$$t = (50\%/100\%) \cdot 30 = 15$$

Entering Table I at Order No. 15, he finds he should reduce them by 4.2%.

TABLE I

VALUES OF D FOR A NEW ENGLAND CONTRACTOR

Order No.	D	Order No.	D	Order No.	D
1	-5.2	11	2.1	21	7.6
2	-1.4	12	2.8	22	9.7
3	-1.0	13	3.8	23	9.7
4	-0.3	14	3.8	24	12.3
5	0.0	15	4.2	25	14.4
6	1.1	16	4.4	26	14.7
7	1.3	17	5.6	27	15.7
8	1.4	18	6.6	28	16.4
9	1.6	19	7.3	29	20.4
10	1.9	20	7.5	30	22.9

Critique. Every contractor is to some degree specialized, that is, more suited for one type of project than another, if not by design, then by experience. He may have been involved in more resurfacing projects than other kinds and thus his equipment and experience are more oriented in this direction, i.e., he knows more "tricks of the trade" for this type of project. Since every project is different, the cost estimates of the contractor for his specialty type of project should be lower than that of his competitor who is not as well suited. The degree to which his estimate is

lower than that of his lowest competitor may correspond to the degree by which the project is closer to his specialty than that of his competitor. The reverse is, of course, also true.

A contractor may be justified in reducing his bid a certain amount for those projects which he and his competitor are nearly equally suited in order to win a greater percentage of them. However, he would be well advised to relate the percent reduction to the relative degree by which he and his competitor are suited. Indeed, it would not be logical for him to reduce his bid in projects of his specialty as this model would have him to do; he might expect to win these projects anyway. In fact, if he could identify the degree to which the projects relate to his specialty, he would be able to increase his overall profit and winning percentage by increasing or decreasing his bid corresponding to the degree of the relationship.

It might be noted that, if the magnitude of D is related to the relative relationship of the project to his specialty, then the percent bid reduction obtained from Table I will not provide a long-term winning percentage of p unless he bids on the same mix of projects (relative to his specialty) in the future. Thus, it would seem that the major failure of Gates' introspection approach is that it fails to relate D to the characteristics of the project, i.e., the contractors specialty.

A New Competitive Bidding Model

Each of the three procedures described above have one or more difficulties so that they cannot be easily used in bidding for highway construction projects. Generally, these problems arise from the method used to estimate P(x), the probability of winning the project as a function of the bid value. Ideally, this estimate should be (1) independent of the estimate of the project cost by the contractor, and (2) independent of the number or identity of the competing bidders.

Estimating P(x) independently from the estimate of the project cost would eliminate the problems encountered in Gates' Least Spread Theory. The overall optimal profit for each project could be estimated rather than the additional percent profit to add to the bid after its "final" size had already been set. In addition, if the project costs are too high, because of an error in the estimating procedure or because the organization is not suited for that type of project, this will be indicated by a very low probability of winning.

An independent estimate would also give the contractor much more flexibility than he has in Gates' Introspection Approach. It is reasonable to assume that, for a given probability of winning, a contractor can make more profit on a project suited to him than on one less suited to his particular specialty. An independent estimate of P(x) would allow him to determine the relative match of the

project to his specialization. The contractor could then choose between several bidding strategies. For example, he could maximize his expected profit from all bids for a given share of the market (fixed probability of winning), or he could maximize his share of the market for a fixed profit level.

Evaluating P(x) independently of either the identity or number of competitors would eliminate the major problem associated with Friedman's Competitor Model. A complete file on all competitors would be impossible to maintain because new firms may at any time enter the competition, or established firms from other states may decide to expand into a new area. This is not to say a file on one's competitors is not necessary. On the contrary, the more a contractor knows of his competitors and of his industrial environment, the more realistically he may evaluate his chances of winning. The computed estimate is just one of the factors in consideration.

It is hypothesized that P(x) can be estimated so as to satisfy the criteria stated above, estimated independently of the identity and number of competitors and of the estimate of the project cost, by first estimating the bid of the lowest competitor as a function of the characteristics of the project by means of a regression analysis. A probability distribution can be determined for each regression estimate from which the probability of winning the project as a function of the bid value can be evaluated.

A description of each project to be bid upon is sent the various contractors by the state, and contains a list of work elements (cubic yards of excavation, etc.) required of the contractor by the project. No two projects will be exactly the same. After the project is let, the bid of each contractor for each project is tabulated and made available to any concerned individual as a public document. The data necessary to develop the regression equations can be obtained from these tabulations. The characteristics of the project, the work items, will be the independent variables; the dependent variable will be the bid value of the lowest competitor. For the purpose of this thesis, the bid value of the lowest bidder will be the same as for the lowest competitor. In practice, a contractor using this approach would not use his own bids in the development of the regression equation, even if he were the low bidder. The regression equation is to estimate the bid of his lowest competitor, not the low bid for a particular project.

The immediate intent of the analysis will be to eliminate independent variables having no significant effect on the estimate of the low bid, to isolate bidding trends in the data, and to test for significant classifications in the data. The ultimate intent will be to estimate the low bid for a project based on its characteristics and to use these results to estimate P(x), the probability of winning the project with a bid of x.

CHAPTER II

HIGHWAY PROJECT CHARACTERISTICS

Introduction

About three weeks prior to a specific letting, a "Notice to Contractors" is sent to all contractors by the State Highway Department. This document lists all the projects which are to be let that particular month, and for each provides such information as: a brief project description, location, working days restriction (or date project must be completed), approximate magnitude of each of the work items required by the project, and the highway engineer's estimate of the total project cost. This notice contains all of the information needed by a contractor using the model proposed in this study to estimate the bid of his lowest competitor and P(x), the probability of winning the project. Three pages of such a notice has been extracted to illustrate the form in which this information comes to the contractor. These pages are presented in Appendix B. The first page summarizes the projects to be let November 26, 1968. This listing is continued for four additional pages. In all, 40 projects were let on that date. The dollar value is the engineer's estimate of the project cost. Following the initial listing, additional details

are given for each project. The last two pages of Appendix B, concerning project S-39(15)S, informs the contractor of certain legal obligations and the work requirements of the project.

If a contractor is interested in one or more of the projects listed, he requests and is sent a "Proposal" and a detailed set of plans for each. The contractor actually bids on the dollar rate for which he will perform each of the work requirements of the project, rather than the total amount of each item. For example, he will bid $0.40 per cubic yard of unclassified excavation, rather than $5,923.20 for the estimated total of 14,808 cubic yards. This is because the total quantity of each work item is only an estimate and will be expected to vary somewhat during actual construction. A state project engineer, assigned to the project, will measure the exact amounts as construction proceeds so that fair compensation is made to the contractor. The total dollar amount for the estimated quantities (the $5,923.20) is also computed, then the totals summed to determine the project bid, and subsequently, the winner.

This method of bidding, unit bidding, opens possibilities of the contractor increasing his profit for a bid of a given size. The state generally pays the contractor periodically, say quarterly, for the work he has accomplished. By putting most of the profit into the unit bids of the items to be completed first, the contractor will have a faster return from the project, increasing his profit by

reinvesting this money elsewhere. This procedure is called unbalanced bidding and will not be investigated further in this study.

After all bids for all projects let on a particular date have been collected and read, they are tabulated, reproduced and sent to any interested persons. The bid tabulation books contain all the information shown in Appendix B as well as the following for each project.

(1) a specification number for each work item

(2) the highway engineer's estimate of the unit rate for each work item

(3) the highway engineer's estimate of the total cost for each item

(4) each contractor's unit bid for each item

(5) each contractor's total for each item

(6) each contractor's total for the project.

Project Classifications

The bid tabulations for all lettings in Oklahoma for the years 1964, 1965, 1966, and 1967 were obtained from the Oklahoma State Highway Department. The data obtained from the first three years were used to develop the proposed model, and that from the last year were used as independent information to test its validity. There were a total of 1107 projects let during the four year period. The number of projects let each month of each year, and hence the

number of projects in each tabulation book, is shown in Table II.

TABLE II

MONTHLY LETTINGS OF PROJECTS*

Month	1964	1965	1966	1967	
Jan.	28	8	26	19	
Feb.	22	29	21	13	
March	27	24	51	14	
April	20	13	36	24	
May	31	22	18	29	
June	34	26	23	33	
July	14	29	32	34	
Aug.	22	16	29	19	
Sept.	20	17	16	26	
Oct.	9	16	7	13	
Nov.	32	29	21	16	
Dec.	23	24	31	21	
Totals	282	253	311	261	1107

*Does not include projects for which no bids were received or which were withdrawn.

Each project in the bid tabulation book contains a brief description, similar to those on the first page of Appendix B. From these descriptions, nineteen categories were defined and the number of projects falling into each was counted. The results of this count are given in Table III.

Because of the large number and variety of the construction projects during the four year period, it was decided to limit the scope of this study to those projects which only involved base construction and paving, categories G, I, K, M, and O in Table III. Categories G, I, and K were subsequently combined into a single classification, Secondary Bituminous Pavements. This selection eliminated a number of factors which might otherwise require consideration. Among these are: rock excavation, clearing and grubbing, drainage structures, overpasses, etc. Presumably, for the paving projects, the land has been cleared and a grade constructed during previous projects so that these factors, while still remaining but in relatively minor amounts, have greatly diminished in importance.

Work Item Identification

One of the difficulties in identifying the different work items in the bid tabulation books is that two or more may have identical descriptions. The problem is alleviated some in that the work items which do have the same descriptions have different specification numbers. Unfortunately,

TABLE III

PROJECT LETTINGS BY CATEGORY

	Category Description	1964 1965 1966	1967	Total
A.	Grading, Drainage	94	35	129
B.	Bridge Construction	202	71	273
C.	Bridge Repair	9	0	9
D.	Grad., Drain., Armor Coat	7	0	7
E.	Armor Coat	12	0	12
F.	Grad., Drain., Traffic Bnd. Surf.	0	0	0
G.	Traffic Bnd. Surf.	7	0	7
H.	Grad., Drain., Sin. Bitum Surf. Coat	12	7	19
I.	Sin. Bitum. Surf. Coat	23	9	32
J.	Grad., Drain., Double Bitum. Surf. Coat	22	0	22
K.	Double Bitum. Surf. Coat	8	0	8
L.	Grad., Drain., P. C. Conc. Surf.	29	3	32
M.	P. C. Conc. Surf.	31	9	40
N.	Grad., Drain., Asph. Conc. Surf.	19	5	24
O.	Asph. Conc. Surf.	46	26	72
P.	Widening, Resurfacing	100	31	131
Q.	Erosion Control	116	34	150
R.	Signing, Stripping, Etc.	89	29	118
S.	Miscellaneous	20	2	22
		846	261	1107

two or more work items with different descriptions could have the same specification numbers, however, the pair, the description and the specification numbers, do form a unique couple and can be used to completely determine a unique work item. The unique couples have been given a code number (or item number) by the state highway department, and a listing of all work items with their associated specification and code numbers is given in Standard Specification Bid Items, a publication of the Oklahoma Highway Department. In general, the work items in this study will be referred to by only their code number.

The work items in each paving project were identified by their code numbers and a complete listing is given in Appendix A. There were a total of 239 distinct work items required during the four year period in the paving projects. It should be noted in reading this Appendix, and where appropriate in the text of this study, that the highway designation of the project was not retained. Instead, to facilitate quick referencing to more complete information on a project, a coding system was developed so that the first two digits represent the month the project was let, the next two the year (the first four specify a particular bid tabulation book), and the last three, the page number in the tabulation book on which the information begins for that particular project.

As was expected, each project required, in general, a different combination of the work items, with some items

appearing more frequently than others. A large number of items appeared only once during the four year period. A count was made of the number of times each work item was required by each of the three different types of pavement projects during the three year period 1964 through 1966; the results are given in Table IV. A zero in the total column indicates the item was required in one or more projects let in 1967.

TABLE IV

WORK ITEM OCCURRENCE

Item	Conc.	Asph.	Sec. Bitum.	Total	Item	Conc.	Asph.	Sec. Bitum.	Total	Item	Conc.	Asph.	Sec. Bitum.	Total
570	31	46	16	93	574	31	46	16	93	572	31	44	17	92
102	31	40	13	84	205	30	41	8	79	206	29	41	8	78
207	30	41	7	78	130	32	33	13	78	176	15	34	27	76
204	20	33	22	75	240	12	46	0	58	712	16	28	14	58
238	11	43	0	54	161	10	3	37	50	141	10	3	35	48
805	11	18	8	37	236	5	36	0	41	104	22	17	2	41
166	15	22	2	39	162	13	22	0	35	163	13	22	0	35
168	14	22	1	37	164	13	19	0	32	275	9	23	3	35
302	9	21	2	32	250	25	14	0	39	103	4	13	1	18
157	10	3	16	29	165	5	13	0	18	278	10	16	4	30
119	6	18	8	32	447	14	15	0	29	766	6	16	8	30
135	28	0	2	30	140	28	0	1	29	241	5	20	0	25
448	14	15	0	29	767	5	10	12	27	172	6	19	0	25
173	6	19	0	25	201	1	0	17	18	202	1	0	17	18
430	12	10	1	23	729	7	15	3	25	740	5	9	4	18
105	6	12	1	19	353	0	4	7	11	150	0	0	19	19
139	20	0	0	20	465	7	8	1	16	738	4	14	1	19
735	4	10	4	18	249	12	7	0	19	137	18	0	0	18
470	7	7	1	15	149	10	3	3	16	217	0	5	13	18
644	7	10	1	18	136	16	0	1	17	219	0	4	13	17
222	0	4	13	17	223	0	4	13	17	732	2	4	4	10
106	0	0	6	6	129	0	9	5	14	770	1	1	4	6
263	7	6	0	13	179	0	0	13	13	715	0	10	0	10
726	2	7	0	9	501	4	5	1	10	502	5	5	1	11
111	0	7	0	7	117	0	4	5	9	259	7	3	0	10
704	5	3	0	8	153	0	0	10	10	276	0	0	0	0
317	2	5	0	7	113	0	7	1	8	145	0	0	8	8
158	0	0	8	8	436	2	2	0	4	839	4	3	1	8
138	6	0	1	7	457	0	4	3	7	651	1	4	0	5
479	2	3	1	6	248	4	0	0	4	260	5	0	0	5
344	1	2	0	3	435	1	1	0	2	466	2	3	0	5
575	3	3	0	6	768	1	2	0	3	318	6	4	0	10
429	0	0	0	0	444	1	4	0	5	463	2	2	0	4
477	2	2	0	4	658	4	0	0	4	663	4	0	1	5
673	1	1	0	2	724	1	4	0	5	730	1	2	0	3
838	3	1	0	4	857	0	3	0	3	115	1	2	0	3
237	0	0	0	0	274	2	2	0	4	343	2	2	0	4
432	1	0	0	1	442	1	0	1	2	461	3	2	0	5
558	1	2	1	4	654	1	2	1	4	665	3	1	0	4
678	1	2	0	3	703	4	0	0	4	769	1	2	0	3

TABLE IV (Continued)

Item	Conc.	Asph.	Sec. Bitum.	Total	Item	Conc.	Asph.	Sec. Bitum.	Total	Item	Conc.	Asph.	Sec. Bitum.	Total
840	3	0	0	3	848	3	0	0	3	110	0	0	0	0
118	0	3	0	3	156	0	0	1	1	262	2	1	0	3
319	2	1	0	3	467	0	3	0	3	468	2	0	0	2
650	1	2	0	3	666	2	1	1	4	667	1	1	1	3
713	2	0	0	2	739	0	0	2	2	759	0	2	0	2
819	0	1	0	1	853	2	1	0	3	858	1	3	0	4
148	0	0	0	0	209	0	0	2	2	316	1	0	0	1
352	1	0	0	1	433	2	0	1	3	441	0	0	0	0
445	1	0	0	1	464	1	0	1	2	508	1	0	0	1
511	1	0	1	2	559	1	1	1	3	560	0	0	0	0
646	0	1	0	1	655	2	0	0	2	662	2	0	0	2
668	3	0	1	4	669	1	0	1	2	676	1	0	0	1
709	1	0	0	1	777	2	0	0	2	841	1	0	0	1
849	2	0	0	2	859	0	2	0	2	866	0	1	0	1
867	1	0	1	2	701	0	0	0	0	174	0	0	0	0
121	0	0	0	0	146	0	0	1	1	155	0	0	1	1
218	0	1	0	1	247	1	0	0	1	258	1	0	0	1
277	0	1	0	1	315	1	0	0	1	326	1	0	0	1
340	1	0	0	1	345	0	1	0	1	356	0	1	0	1
401	1	0	0	1	415	1	0	0	1	418	0	1	0	1
431	1	0	0	1	449	1	0	0	1	453	0	0	0	0
455	0	0	0	0	462	0	2	0	2	471	0	0	0	0
476	1	0	0	1	503	0	1	0	1	505	0	1	0	1
506	0	1	0	1	515	1	0	0	1	524	0	0	0	0
557	0	1	0	1	561	1	0	0	1	577	1	0	0	1
612	1	0	0	1	617	1	0	0	1	622	1	0	0	1
627	1	0	0	1	645	1	0	0	1	647	1	0	0	1
648	0	0	0	0	653	1	0	0	1	657	1	0	0	1
679	0	0	0	0	705	1	0	0	1	616	0	1	0	1
733	0	0	1	1	748	1	0	0	1	749	1	0	0	1
778	1	0	0	1	779	1	0	0	1	828	0	0	1	1
829	0	1	0	1	846	0	0	0	0	854	0	0	0	0
861	0	1	0	1	862	0	1	0	1	863	0	1	0	1
864	1	0	0	1	865	1	0	0	1	868	1	0	0	1
869	0	0	0	0	870	0	0	0	0	871	0	0	0	0
872	0	0	1	1	873	0	0	1	1	874	0	0	1	1
875	0	0	2	2	876	0	0	2	2	802	0	0	0	0
507	0	0	0	0	253	0	0	0	0	372	0	0	0	0
674	0	1	0	1	254	1	0	1	2	744	1	0	0	1
244	1	0	0	1	522	1	0	0	1					

CHAPTER III

ESTIMATING THE LOW BID

The Stepwise Regression Procedure

One of the difficulties encountered in estimating a low bid by a regression analysis is that there are usually a much larger number of potential independent variables than there are observations. For the 115 projects selected for analysis in this study, 215 work items were required over the three year period. Even by rejecting from consideration those items which only rarely occured, a large number remained. While a regression equation involving numerous variables would normally be expected to yield a high degree of precision, this may not be the most desirable result. First, a large number of variables would greatly increase the difficulty of applying the final model, and thus may influence the decision of whether to use this approach at all. Second, a complex equation may include among the variables, several which do not significantly increase the precision of the estimate. Ideally, the regression equation should not include variables which do not significantly increase the precision of the estimate. Because of these two compromising considerations, a procedure was used which not only performed the required regression analysis, but which

also selected the variables to be used in the regression equation from a population of candidate variables, using as a criteria, their ability to improve the "goodness of fit" of the equation. The procedure used was the Stepwise Regression procedure.

The Stepwise Regression procedure involves a number of steps, each requiring the calculation of a new regression equation. Each regression equation differs from the succeeding or preceding one in that a different combination of variables are involved; either one less or one more. At each step of the procedure, every variable currently in the regression equation is tested to determine its effect on the variance of the dependent variable as if it were the last one to enter the equation. If one is found to be ineffective, i.e., the amount of the variance reduction does not compare favorably to a predetermined F level, the next step of the procedure will be to delete this variable from the equation. If none are found, then the procedure will select the one variable from the candidate variables which gives the greatest reduction in the variance of the dependent variable, i.e., the greatest improvement in the "goodness of fit." If the improvement is significant as measured by the predetermined F level, then the variable is entered into a new regression equation. If it is not significant, then the procedure terminates. Thus, at the various steps in the regression procedure, only those variables which are significant at the specified F level are included in the regression

equation.

The predetermined F level in this study was set to provide a level of significance, α, of approximately 0.10. The significance level could only be approximately determined because the F level, entered into the computer program as a constant, should theoretically change with each new variable entered into or deleted from the regression equation. However, because of the large number of degrees of freedom in the regression analyses in this study, the lack of change in the predetermined F level does not appreciably change the significance level as the stepwise procedure goes from one step to the next. For example, for $\alpha = .10$, $F_{1,120}$ is 2.75 and $F_{1,60}$ is 2.79.

A computer program was obtained to perform the Stepwise Regression procedure (6). This program has features other than those required by the stepwise process. Those which were used in this study are discussed at the points that they are relevant.

Regression I. No Classification

For the first regression analysis, no attempt was made to classify the projects in any manner. All 115 projects were used, each representing one observation; 95 different work items were selected as potential candidates for the regression equations. The remaining 120 work items were rejected as candidates because they were considered as "rare" requirements. An arbitrary decision had been made

to reject as rare all work items which were required in five or fewer projects during the three year period.

Four additional variables were included in the analysis along with the 95 work items. They were:

(1) Length of the project in miles.

(2) Month the project was let (January = 1, February = 2, ..., December = 12.)

(3) Year the project was let (1964 = 1, 1965 = 2, 1966 = 3).

(4) The Highway Engineer's Estimate of the total project cost.

The Highway Engineer's Estimate was included because none of the other work items in any way reflect factors which might cause the construction of one project to be more difficult than another similar one. These factors are obvious to the Highway Engineer and to the contractor and would show up as a slight increase or decrease in the estimate (or bid) value. Job difficulty factors would include such considerations as: location, terrain, adjacent sections, available materials, access roads, traffic control during construction, etc. These factors would be difficult to identify and to measure for a given project from the list of work items. In the final analysis, only with experience would one be able to assess the importance of these factors relative to a particular project. Presumably, these factors have been taken into consideration by the Highway Engineer and are, to some extent at least, reflected in his estimate of the project cost. Thus, the utilization of this variable is expected to bring into the regression equation some

measure of the project difficulty.

The results of this regression analysis are summarized in Tables V, VI, and VII. A complete printout of the results, giving project designation, actual low bid, the Highway Engineer's estimate, the regression estimate, and the percent deviation each of the two estimation methods are from the actual low bid is tabulated in Appendix C. The percent deviation was computed from the equation.

$$\text{Percent Deviation} = [(\text{low bid} - \text{estimate})/\text{low bid}] \cdot 100\% \tag{3.1}$$

The estimate is either the engineer's estimate or the regression estimate, whichever is appropriate. It should be noted when reading these tables that an overestimate is indicated by a minus (-) sign.

TABLE V

REGRESSION I. AOV

Source	df	SS	MS	Overall F
Total (Corrected)	114	1572E+10		
Due to Regression	17	1571E+10	9246E+08	26776.
Residual	97	3382E+06	3453E+04	

TABLE VI

REGRESSION I. PERCENT DEVIATIONS

Estimation Method	Concrete Avg.	Concrete St. Dv.	Asphalt Avg.	Asphalt St. Dv.	Sec. Bitum. Avg.	Sec. Bitum. St. Dv.
Eng. Est.	-3.81	7.79	-7.43	9.05	-11.08	8.49
Reg. I	0.10	4.29	0.14	5.22	0.86	10.38

In Table V, the magnitudes of the sum of squares and of the mean squares are very large. Many of the digits do not meaningfully contribute to the calculation of the overall F value, so they have been rounded off and the decimal point located as is customary in FORTRAN "E" format. For example, 10^{+4} is represented by E+04, and 10^{-6} by E-06. This convention will be used where appropriate in this chapter. All of the digits, rather than the rounded numbers, were used for any computations needed to complete the table. The E convention is used only for presentation. It can be seen in this table that the variance reduction due to regression has an α level of essentially zero. Most of this variance reduction is attributed to the engineer's estimate. This result is not surprising since it might be expected that this variable would be highly correlated to the actual low bid. The variance is also reduced a significant amount by each of the other variables; this is guaranteed by the

inclusion of these variables in the regression equation by the stepwise procedure.

The percent deviations were classified depending on the type of pavement required by the project. These results are summarized in Table VI. In each of the three categories, the highway engineer tended to overestimate the low bid for the project. Again, this is not a particularly surprising result since the highway engineer's estimate is included with the information sent to the contractors. A contractor might feel he must underbid the engineer's estimate, at least, if he is to have a chance to win the project. In only 14 of the 115 projects did the highway engineer underestimate the low bid. The average percent deviation will be interpreted as a measure of the bias of the estimation method, the standard deviation as a measure of the precision of the method.

Examining Table VI, it does not appear that the regression equation gave equally good results, with respect to the standard deviation, for the three classifications. In particular, the standard deviation for the secondary bituminous projects is larger than the engineer's estimate for that category, and twice as large as for the regression estimate for the other two categories. This would indicate that there might be differences in the three classifications and that they should be treated separately. To test this conjecture, an analysis of covariance was performed using the variables found significant in the regression analysis as

TABLE VII

REGRESSION I. REGRESSION EQUATION

Variable	Coefficient	St. Error	Variable Description
Constant	3959.044		
EE	1.048	0.017	Engineers Estimate
X(176)*	- 42.618	11.906	Traf. Bound Surf. Cse., Type A
X(141)	- 0.061	0.011	Asph. for Stabilization
X(236)	- 3.488	0.630	Aggr., Type A
X(104)	0.576	0.098	Class "D" Uncl. Exc. (Select Mat'l)
X(250)	- 0.920	0.107	9" P. C. Concrete Pavement
X(165)	- 0.291	0.126	Prime Coat
X(767)	-140.277	59.848	Delineators - Type 1-A
X(173)	- 16.341	3.168	Asph. for Asphaltic Blk. Base (HM-HL)
X(430)	2.020	0.880	6" Integral Curb
X(139)	- 1.183	0.591	Processing (Shoulders)
X(263)	6.252	1.455	4" Lip Curb
X(715)	- 8.830	3.232	R.O.W. Fence (Des. 1 or 2)
X(776)	-333.644	159.234	R.O.W. Markers
X(111)	8.979	4.300	Salvaged Topsoil
X(259)	11.140	3.118	8" H.E.S. Conc. Pav't. (AE Agent)
X(138)	1.813	0.409	Processing (Under Slab)

*The number in parentheses is the Highway Code number for that work item.

the co-variables.

Covariance analysis is useful in those situations in which the response variable must be adjusted to take into consideration variations in the experimental material. In this study the project low bids in each of the classifications will be adjusted to take into consideration that each project requires a varying amount of work, as measured by the magnitude of the various work items. The assumptions necessary to validly use this procedure are:

(1) Homogenity of the regression coefficients, i.e., variable X_i will have the same coefficient in each of the classifications.

(2) The covariables are measured without error.

(3) The error is normally distributed with mean zero and variance σ^2, i.e., $\epsilon_i \sim N(0,\sigma^2)$

(4) Regression of Y on X after removal of the treatment differences is linear and independent of the treatment.

The last three assumptions will be accepted, the first, however, will be tested. The covariance analysis requires a matrix be constructed for each of the classifications and for the classification totals. The elements of such a matrix are the residual sums of squares and cross products for the appropriate classification. By manipulation of these matrices, the quantities necessary for testing for homogenity of regression coefficients and for treatment effects may be obtained. The covariance analysis is summarized in Table VIII.

TABLE VIII

COVARIANCE ANALYSIS

Source	df_1	df_2	SS
Total	114		
Pavements	2		
Error	112	95	334.123
Concrete	30	13	118.081
Asphalt	45	28	66.203
Second Bitum.	37	20	3.574
Within RSS		61	187.858
Difference RSS		34	146.265
Pavements + Error		97	405.583
Difference		2	71.460

(A) Test of the hypothesis of homogenity of regression coefficients among the classifications.

H_o: $\beta_{1,1} = \beta_{1,2} = \beta_{1,3}$ $\quad \vdots \quad$ $\beta_{17,1} = \beta_{17,2} = \beta_{17,3} = \beta_{17}$

H_a: At least one equality not true

$$F_{(34,61)} = (146.265/34)/(187.858/61) = 1.40$$

$$F_{(34,61,.90)} = 1.46$$

The calculated F value has a significance level greater than $\alpha = .10$. Therefore, H_o will not be rejected.

(B) Test of the hypothesis of treatment effects.

H_o: There are no differences in the three types of paving projects.

H_a: There are differences in the three types of paving projects.

$$F_{(2,95)} = (71.460/2)/(334.123/95) = 10.27$$

$$F_{(2,96.90)} = 2.36$$

Clearly, H_a may be accepted, i.e., there are significant differences in the responses of the three types of paving projects.

Regression II. Projects Classified as to Pavement Type

A regression analysis was performed separately for each of the three types of paving projects. The variables considered as candidates in the regression equations were those work items which most frequently occurred in the appropriate type of project. Reference to Table IV will indicate the frequency of occurrence of each work item in each project type. Those work items which rarely occurred were again rejected as possible candidates. In addition to the work items, the four variables defined for Regression I, project length, month and year project was let, and engineer's estimate, were also included in the analysis.

The results of these regression analyses are summarized in Tables IX, X, and XI. A complete printout of the results is tabulated in Appendix C. Table X indicates a definite reduction in the standard deviation for the secondary bituminous paving projects. Very little change was noted in the other two types of paving projects.

TABLE IX

REGRESSION II. AOV

Source	df	SS	MS	Overall F
Concrete				
Total (Corrected)	30	2383E+09		
Due to Regression	6	2361E+09	3835E+08	419.
Residual	24	2253E+08	9389E+05	
Asphalt				
Total (Corrected)	45	6632E+09		
Due to Regression	11	6622E+09	6021E+08	2342.
Residual	34	8742E+06	2571E+05	
Sec. Bitum.				
Total (Corrected)	37	1760E+08		
Due to Regression	7	1758E+08	2512E+07	4139.
Residual	30	1821E+05	607E+00	

TABLE X

REGRESSION II. PERCENT DEVIATIONS

Estimation Method	Concrete Avg.	Concrete St. Dv.	Asphalt Avg.	Asphalt St. Dv.	Sec. Bitum. Avg.	Sec. Bitum. St. Dv.
Eng. Est.	-3.81	7.79	-7.43	9.05	-11.88	8.49
Reg. I	0.10	4.29	0.14	5.22	0.86	10.38
Reg. II	-0.46	5.31	0.27	4.47	- 0.60	4.33

Regression III. Elimination of the Engineer's Estimate from the Regression Equation

A regression analysis was performed on each of the three types of paving projects, as in Regression II, however, this time the engineer's estimate was not included as a candidate for the regression equation. All other variables included in the previous analyses were also included in these analyses. The purpose of this set was to determine the effectiveness with which the difficulties in construction of the project are represented by the engineer's estimate. When this variable is included in the regression equation, it can be interpreted as estimating the low bid while the other variables in some manner become correction factors. Without this variable, the cost of the project must be estimated directly from the magnitude of the work items. In this case, no consideration is given to project

TABLE XI

REGRESSION II. REGRESSION EQUATION

Variable	Coefficient	St. Error	Variable Description
Cement			
Constant	30967.		
EE	1.034	0.036	Engineers' Estimate
X(250)*	- 1.079	0.198	9" P.C. Conc. Pav't. (AE Agent)
X(165)	- 0.845	0.472	Prime Coat
X(263)	6.845	2.663	4" Lip Curb
X(138)	2.286	0.665	Processing (Under Slab)
X(176)	- 56.839	30.513	Traf. Bound Surf. Cse., Type A
Asphalt			
Constant	-16174.		
Year	12559.585	4686.302	Year Project was Let
EE	1.095	0.038	Engineers' Estimate
X(204)	- 1.037	0.248	Prime Mat'l.
X(240)	97.736	26.133	Asph. (85 to 100 Penetration)
X(238)	- 3.056	1.368	Aggr., Type C
X(236)	- 8.170	1.367	Aggr., Type A
X(104)	0.924	0.128	Class "D" Uncl. Exc. (Select Mat'l)
X(168)	0.092	0.053	Lime Treatment of the Subgr.
X(165)	- 1.772	0.316	Prime Coat
X(767)	- 252.057	123.989	Delineators - Type 1-A
X(172)	- 0.773	0.149	Aggr. for Asphaltic Blk. Base (HM-HL)

TABLE XI (Continued)

Variable	Coefficient	St. Error	Variable Description
Sec. Bitum. Constant	4517.		
EE	0.871	0.016	Engineers' Estimate
X(130)	- 0.035	0.016	Subgr., Method B
X(204)	- 0.091	0.050	Prime Mat'l.
X(141)	- 0.014	0.006	Asph. for Stabilization
X(119)	- 0.130	0.071	Subbase
X(150)	- 0.096	0.020	Suit. Soil for Soil Asph. Base (8")
X(158)	0.090	0.021	Manipulation (8")

*The numbers in parentheses refer to the Highway Code number for that work item.

difficulty factors.

The results from these regression analyses are summarized in Tables XII, XIII, and XIV. A complete printout of the results is contained in Appendix C. It is immediately apparent in Table XIII that a large increase has occurred in the variability of regression estimates for both the asphalt and secondary bituminous types of paving projects. Very little change was observed in the variability of the concrete projects. These changes are also noted when Tables IX and XII are compared. The ratios of the mean squares for the corresponding categories are:

Concrete: $F_{(24,20)} = 93891/90865 = 1.03$

$F_{(24,20,.90)} = 1.77$

Asphalt: $F_{(32,34)} = 81506/25712 = 3.17$

$F_{(32,34,.90)} = 1.59$

Sec. Bitum: $F_{(29,30)} = 16773/607 = 2.78$

$F_{(29,30,.90)} = 1.61$

In general, it seems desirable to include the engineer's estimate in the regression equation.

TABLE XII

REGRESSION III. AOV

Source	df	SS	MS	Overall F
Concrete				
Total (Corrected)	30	2383E+09		
Due to Regression	10	2365E+09	2365E+08	206.
Residual	20	1817E+07	9086E+05	
Asphalt				
Total (Corrected)	45	6487E+09		
Due to Regression	13	6461E+09	4970E+08	610.
Residual	32	2608E+07	8151E+05	
Sec. Bitum.				
Total (Corrected)	37	1760E+08		
Due to Regression	8	1711E+08	2139E+07	128.
Residual	29	4864E+06	1677E+05	

TABLE XIII

REGRESSION III. PERCENT DEVIATIONS

Estimation Method	Concrete Avg.	Concrete St. Dv.	Asphalt Avg.	Asphalt St. Dv.	Sec. Bitum. Avg.	Sec. Bitum. St. Dv.
Eng. Est.	-3.81	7.79	-7.43	9.05	-11.88	8.49
Reg. I	0.10	4.29	0.14	5.22	0.86	10.38
Reg. II	-0.46	5.31	0.27	4.47	- 0.60	4.33
Reg. III	-0.33	4.86	0.05	7.42	- 1.72	22.25

TABLE XIV

REGRESSION III. REGRESSION EQUATIONS

Variable	Coefficient	St. Error	Variable Description
Concrete			
Constant	30706.11		
X(102)*	2.650	0.753	Class "D" Uncl. Exc.
X(130)	1.457	0.148	Subgr., Method B
X(204)	4.501	0.404	Prime Mat'l.
X(161)	119.131	25.620	Rolling
X(104)	0.462	0.246	Class "D" Uncl. Exc. (Select Mat'l)
X(166)	188.652	20.565	Lime for Modification
X(164)	15.025	1.818	Tack Coat (Asph. Emul. AE-5)
X(766)	- 809.981	130.002	Delineators - Type 1
X(140)	5.280	0.716	Asph. for Asph. Membrane
X(263)	13.190	3.464	4" Lip Curb
Sec. Bitum.			
Constant	3955.51		
Length	7043.754	2428.343	Project Length
X(570)	22.932	9.010	Pref. Pipe Underdrain
X(206)	37.396	10.855	No. 1 Cover Mat'l.
X(176)	99.724	27.032	Traf. Bound Surf. Cse., Type A
X(141)	0.137	0.028	Asph. for Stabilization
X(805)	-13925.865	7050.201	Field Office & Laboratory
X(119)	0.898	0.400	Subbase
X(153)	- 158.427	39.524	Manipulation (6" x ')

TABLE XIV (Continued)

Variable	Coefficient	St. Error	Variable Description
Asphalt			
Constant	-809.07		
X(102)	2.035	0.335	Class "D" Uncl. Exc.
X(204)	2.904	0.420	Prime Mat'l.
X(240)	326.447	43.744	Asph. (85 to 100 Penetration)
X(712)	- 4.994	2.669	Guard Rail (Galv. Steel or Alumn.)
X(236)	- 9.357	2.364	Aggr., Type A
X(104)	1.659	0.235	Class "D" Uncl. Exc. (Select Mat'l)
X(166)	-268.097	70.369	Lime for Modification
X(168)	3.998	0.857	Lime Treatment of the Subgr. (6")
X(165)	2.708	0.539	Prime Coat
X(119)	1.531	0.284	Subbase
X(766)	626.952	217.858	Delineators - Type 1
X(767)	20.401	3.641	Delineators - Type 1-A
X(738)	495.982	100.348	Vegetative Mulching

*The number in the parentheses refer to the Highway Code number for that work item.

Regression IV. Squares and Cross Products

The computer program selected to perform the stepwise regression analysis had the capability of transforming the input variables by any one of 17 transformation rules. These rules were used only rarely, generally only to code selected variables so that the computer output was more readable. One transformation, used in this analysis, permits one to use, as the regression independent variables, all squares and cross products of designated input variables, as well as the input variables themselves. For example, if z_i, $i = 1,2,3,4$ are input variables, then this transformation would generate 14 regression variables. If the regression variables are represented by x_i, then

$$x_1 = z_1 \qquad x_8 = z_2 \cdot z_3$$
$$x_2 = z_1 \cdot z_1 \qquad x_9 = z_2 \cdot z_4$$
$$x_3 = z_1 \cdot z_2 \qquad x_{10} = z_3$$
$$x_4 = z_1 \cdot z_3 \qquad x_{11} = z_3 \cdot z_3$$
$$x_5 = z_1 \cdot z_4 \qquad x_{12} = z_3 \cdot z_4$$
$$x_6 = z_2 \qquad x_{13} = z_4$$
$$x_7 = z_2 \cdot z_2 \qquad x_{14} = z_4 \cdot z_4$$

If N is the number of input variables, then the number of regression variables generated, k, is

$$k = N(N + 3)/2 \tag{3.2}$$

Two limits written into the program restrict the use of this transformation. First, the maximum value of N is

10 (in this case, k = 65), and second, the maximum number of independent variables allowed by the program is 129. This restricts the number of input variables used with this transformation to 22, sets of 10, 9, and 3. Of course no cross products could be generated between variables in different sets. These restrictions limited the number of input variables to those items either most frequently used in asphalt projects or to those which were, in past analyses, shown to be significant. No attempt was made to generate all possible cross products of the variables.

The results of this analysis are summarized in Tables XV, XVI, and XVII. A complete printout of the results is contained in Appendix C. Table XVI clearly shows that the standard deviation of the percent differences has been reduced. This change is also noted when Tables IX and XV are compared. The ratio of the mean squares for the asphalt projects is

$$F_{(34,31)} = 25712/11691 = 2.2 \qquad F_{(34,31,.90)} = 1.59$$

One difficulty was noted when the regression equation was examined. While the input variable, i.e., work item, may have frequently occurred in asphalt projects, the occurrence of the regression variable may be rare, that is, very few projects may require both work items z_i and z_j which compose the regression variable $x_k = z_i . z_j$. The investigation of this condition involved the construction of a matrix consisting of zeros and ones. Each row of the matrix

TABLE XV

REGRESSION IV. AOV

Source	df	SS	MS	Overall F
Asphalt				
Total (Corrected)	45	6487E+09		
Due to Regression	14	6484E+09	4631E+08	3961.
Residual	31	3264E+06	1169E+05	

TABLE XVI

REGRESSION IV. PERCENT DEVIATIONS

Estimation Method	Concrete Avg.	Concrete St. Dv.	Asphalt Avg.	Asphalt St. Dv.	Sec. Bitum. Avg.	Sec. Bitum. St. Dv.
Eng. Est.	-3.81	7.79	-7.43	9.05	-11.88	8.49
Reg. I	0.10	4.29	0.14	5.22	0.86	10.38
Reg. II	-0.46	5.31	0.27	4.47	- 0.60	4.33
Reg. III	-0.33	4.83	0.05	7.42	- 1.72	22.25
Reg. IV			-0.20	3.41		

TABLE XVII

REGRESSION IV. REGRESSION EQUATION

Variable	Coefficient	St. Error	Variable Description
Constant	-18123.141		
EE	818.678E-03	33.239E-03	EE: Engineers Estimate
EE·X(240)*	117.622E-06	13.479E-06	YEAR: Year Project was Let
X(104)	227.612E-02	56.514E-02	X(104): Class "D" Uncl. Exc. (Select Mat'l)
X(240)	841.582E+01	156.529E+01	X(165): Prime Coat
X(236)·X(236)	593.593E-06	50.456E-06	X(168): Lime Trt. of Subgr. (6")
X(236)·X(104)	- 48.323E-06	19.562E-06	X(172): Aggr. for Asph. Blk. Base (HM-HL)
X(236)·X(767)	69.486E-03	13.302E-03	X(205): Asph. Binder
X(168)·X(165)	2.229E-06	0.612E-06	X(236): Aggr., Type A
X(168)·X(767)	6.253E-03	2.949E-03	X(240): Asph. (85 to 100 Penetration)
X(165)	- 859.935E-03	119.351E-03	X(275): Class A Conc.
X(205)·X(275)	12.446E-04	6.750E-04	X(162): Aggr. for Sand Asph. Base (HM-HL)
X(712)·X(162)	4.333E-05	1.680E-05	X(767): Delineators - Type 1-A
X(172)	- 22.459E+02	12.170E+02	X(712): Guard Rail (Galv. Steel or Alumn.)
YEAR	95.709E+02	29.455E+02	

*The number in parentheses refer to the Highway Code number for that work item

represents a project and each column one of the work items appearing in the regression equation, Table XIX. If a 1 appears in cell (i,j), then project i requires work item j. Otherwise this cell will contain a zero. By examining the appropriate pairs of rows, the number of projects containing both items j and k may be counted. The results of this count are shown in Table XVIII, and the matrix in Table XIX. It can be seen in Table XVIII that several of the item pairs occur only infrequently in the asphalt projects. The most notable is combination X(168)·X(767) which occurs in only three projects. Regression variables, formed by the product transformation of the work items, which occur so infrequently should not be considered as candidate variables for the regression equation since they constitute "rare" requirements.

Regression V. Subclassifications in Asphalt Paving Projects

A reexamination of the project descriptions for the asphalt projects revealed that three different base courses were used in their construction: asphaltic black base, sand asphalt base, and stabilized aggregate base. When the projects in Table XIX were classified as to the type of base, a definite segregation of certain of the work items became apparent. This might indicate that a base classification could be meaningful when developing the regression equation. It was also noted that nearly all of the black base projects

TABLE XVIII

OCCURRENCE OF WORK ITEM COMBINATIONS
IN ASPHALT PROJECTS

Variable Combination	Occurrence
EE	46
EE·X(240)	46
X(104)	17
X(240)	46
X(236)·X(236)	34
X(236)·X(104)	14
X(236)·X(767)	7
X(168)·X(165)	8
X(168)·X(767)	3
X(165)	13
X(205)·X(275)	21
X(712)·X(162)	12
YEAR	46

TABLE XIX

OCCURRENCE OF SELECTED WORK ITEMS

Type of Base Construction	Project	EE	Yr	X(104)	X(165)	X(168)	X(172)	X(205)	X(236)	X(240)	X(275)	X(162)	X(767)	X(712)
Asphaltic Black Base	0264023	1	1	1	0	0	1	1	1	1	1	0	0	1
	0264029	1	1	1	0	1	1	1	1	1	1	0	0	0
	0264035	1	1	1	0	0	1	1	1	1	0	0	0	0
	0264017	1	1	0	0	0	1	1	1	1	1	0	0	1
	0364005	1	1	1	0	0	1	1	1	1	0	0	0	1
	0464015	1	1	1	0	1	1	1	1	1	0	0	0	0
	0464023	1	1	1	0	1	1	1	1	1	0	0	0	0
	0464071	1	1	0	0	0	1	0	0	1	1	0	1	1
	0564033	1	1	1	0	0	1	1	1	1	0	0	0	0
	0564037	1	1	0	0	0	1	1	1	1	0	0	0	0
	0764011	1	1	1	0	0	1	1	1	1	0	0	0	0
	0864089	1	1	0	0	1	1	0	0	1	0	0	0	0
	0864083	1	1	0	0	1	1	0	0	1	0	0	1	1
	0964071	1	1	1	0	0	1	0	0	1	0	0	0	1
	0964013	1	1	0	0	1	1	1	1	1	0	1	0	0
	0964009	1	1	0	0	1	1	1	1	1	0	1	0	0
	0964005	1	1	0	0	0	1	1	1	1	0	0	1	1
	1264067	1	1	0	0	0	1	1	1	1	1	0	1	1
	0665087	1	1	0	0	1	1	1	1	1	1	0	0	1
Stab. Aggr. Base	0564053	1	1	0	0	0	0	1	1	1	0	0	1	1
	0864005	1	1	0	0	0	0	1	1	1	1	0	1	1
	0365103	1	1	0	0	1	0	1	0	1	0	0	0	1
	0666115	1	1	1	0	0	0	1	0	1	0	0	0	1
	0866121	1	1	0	0	0	0	1	0	1	0	0	0	1
	0866117	1	1	1	0	0	0	1	0	1	0	0	0	1
	1066019	1	1	1	0	1	0	1	1	1	0	0	0	1

TABLE XIX (Continued)

	Project	EE	Yr	X(104)	X(165)	X(168)	X(172)	X(205)	X(236)	X(240)	X(275)	X(162)	X(767)	X(712)
Type of Base Construction														
Sand Asph. Base	0864137	1	1	0	0	0	0	1	0	1	1	1	0	1
	0864129	1	1	0	0	0	0	1	0	1	1	1	1	1
	0864077	1	1	1	0	1	0	1	1	1	1	1	1	1
	0165029	1	1	0	0	1	0	1	1	1	0	1	0	1
	0465079	1	1	0	0	1	0	1	1	1	1	1	0	1
	0765127	1	1	0	0	1	0	1	1	1	1	1	1	0
	0765083	1	1	0	0	0	0	1	1	1	1	1	1	0
	1065059	1	1	0	1	0	0	1	1	1	0	1	0	1
	0166043	1	1	0	1	1	0	1	1	1	1	1	0	0
	0266023	1	1	0	1	1	0	1	1	1	1	1	0	1
	0366121	1	1	0	1	0	0	1	0	1	0	1	0	1
	0366027	1	1	1	1	1	0	0	1	1	1	1	0	0
	0466033	1	1	1	1	1	0	1	1	1	1	1	0	0
	0466041	1	1	0	1	0	0	1	1	1	1	1	0	1
	0466037	1	1	0	1	0	0	1	1	1	1	1	0	1
	0666131	1	1	0	1	1	0	1	0	1	0	1	0	1
	0666007	1	1	0	1	0	0	1	1	1	1	1	0	0
	0766101	1	1	0	1	1	0	1	1	1	1	1	0	0
	0766091	1	1	1	1	1	0	1	1	1	1	1	0	0
	0766063	1	1	1	1	1	0	1	1	1	1	1	0	1

occurred in 1964 (only one additional project during the next two succeeding years). If the base requirement for asphalt projects changed at the end of 1964, then separate regression equations for each of the base types would be desirable.

A regression analysis was performed for both the black base and sand base projects. A regression analysis was not performed for the stabilized aggregate projects since there were only seven during the three year period. The results of these analyses are summarized in Tables XX, XXI, and XXII. A complete printout of the results is contained in Appendix C.

TABLE XX

REGRESSION V. AOV

Source	df	SS	MS	Overall F
Asphalt (Black Base)				
Total (Corrected)	18	3852E+09		
Due to Regression	6	3849E+09	6415E+08	2239.
Residual	12	3438E+06	2864E+05	
Asphalt (Sand Base)				
Total (Corrected)	19	1488E+09		
Due to Regression	7	1486E+09	2124E+08	1551.
Residual	12	1643E+06	1369E+05	

TABLE XXI

REGRESSION V. PERCENT DEVIATIONS

Estimation Method	Concrete Avg.	Concrete St. Dv.	Asphalt Avg.	Asphalt St. Dv.	Sec. Bitum. Avg.	Sec. Bitum. St. Dv.
Eng. Est.	-3.81	7.79	-7.43	9.05	-11.88	8.49
Reg. I	0.10	4.29	0.14	5.22	0.86	10.38
Reg. II	-0.46	5.31	0.27	4.47	0.60	4.33
Reg. III	-0.33	4.83	0.05	7.42	- 1.72	22.25
Reg. IV			-0.20	3.41		
Reg. V (BB)			-0.36	4.67		
Reg. V (SB)			-0.36	3.88		

The result of the regression analysis for the Sand Asphalt Base compares favorably with that of Regression IV. The mean square errors and the standard deviation of the percent differences are of about the same magnitude. The result for the Asphaltic Black Base is comparable with that of Regression II in which there were no subclassifications in the asphalt pavement projects.

Discussion of the Stepwise Regression Results

The data analysis portion of this study resulted in regression equations to be used for estimating the low bid values of future paving projects. The practicability of

TABLE XXII

REGRESSION V. REGRESSION EQUATIONS

Variable	Coefficient	St. Error	Variable Description
Black Base			EE: Engineers' Estimate
Constant	-10025.013		X(102): Class "D" Uncl. Exc.
X(240)*	- 149.370	21.423	X(104): Class "D" Uncl. Exc. (Select Mat'l)
X(104)	276.227E-02	72.954E-02	X(130): Subgr., Method B
X(104)·X(104)	- 15.881E-06	6.082E-06	X(204): Prime Mat'l.
EE	116.116E-02	4.150E-02	X(205): Asph. Binder
X(767)	- 371.619	178.759	X(206): No. 1 Cover Mat'l.
X(729)	21.641E-02	11.625E-02	X(238): Aggr., Type C
			X(240): Asph. (85 to 100 Penetration)
Sand Base			X(729): Solid Slab Sodding
Constant	3521.896		X(767): Delineators - Type 1-A
X(204)·X(130)	356.986E-08	101.613E-08	
X(205)·X(130)	- 29.743E-07	11.085E-07	
X(205)·X(240)	- 6.801E-04	2.838E-04	
X(206)·X(206)	137.059E-04	120.528E-04	
EE	109.152E-02	2.450E-02	
X(102)	0.952	0.266	
X(238)	- 777.904E-02	165.723E-02	

*The number in parentheses refers to the Highway Code number for that work item.

these models will be confirmed by first comparing the results of the two methods of estimation, the regression estimates and the engineer's estimates, and second by using the regression model to estimate the low bids for the projects, let in 1967, which were not used in the development of the models. The last part of this discussion will be used to discuss the performance of the stepwise regression procedure in developing the regression models.

Comparison of the Results of the Two Methods of Estimation

It is difficult to compare two estimators, the engineer's estimate and the regression estimate, when one or both are biased. In the case of a biased estimator, a value is being estimated, say θ, instead of the true population parameter, θ; the amount of bias is $\theta - \theta$. Since both estimators attempt to measure θ, one method of comparing them is to measure the variability about the true population parameter (7). The measure of this variability is called the mean square error, MSE.

$$\text{MSE}(\hat{\theta}) = E(\theta - \theta)^2 = \sigma_\theta^2 + (\text{Bias})^2 \qquad (3.3)$$

It is clearly seen from the tables of percent deviations that the engineer's estimate is biased for each pavement classification. The regression estimates also appear to have a slight bias associated with them, however, in the long run, it may be that these biases will be essentially zero, if not zero itself. Using the values resulting from

Regression II for the asphalt projects, the MSE for the engineer's estimate (EE) and regression estimate (RE) respectively are estimated as follows:

$$MSE(EE) = (9.05)^2 + (7.43)^2 = 141.6$$
$$MSE(RE) = (4.47)^2 + (0.27)^2 = 20.1$$

The MSE(EE) is seven times that of the MSE(RE). Although these are estimated values, and are expected to vary from year to year depending on the projects making up the sample, it is expected that the regression estimate will remain by far the superior method of estimating the low bid. Similar results are obtained if the results for the cement and secondary bituminous projects are used instead of the asphalt projects.

Prediction of the Low Bid of Future Projects

The ability of the regression equations developed in this study to predict the bid value of the lowest competitor (low bid in this study) was tested by computing the low bids for 17 asphalt pavement projects let during the first nine months of 1967. The data from these projects were not used in the development of the regression equations. These projects were first classified as to the type of base construction, then the low bid predicted using the equations developed in Regression V. The results are shown in Table XXIII. In this table a "B" immediately following the project designation indicates the base was an asphaltic black

TABLE XXIII

PREDICTED LOW BIDS FOR
PROJECTS LET IN 1967

Project	Low Bid	Percent Deviation EE	RE
0767151B	266795.38	- 0.88	1.72
0767067B	431438.57	- 7.38	- 0.46
0167077S	346307.22	4.48	- 3.42
0367083S	543694.17	-22.14	-14.24
0367051S	618863.00	- 2.98	1.70
0667159S	433476.00	-22.44	- 5.25
0667035S	627365.98	-20.72	- 9.81
0667041S	579312.00	-23.06	- 9.32
0667137S	647828.12	-24.87	- 3.76
0667151S	571124.31	-27.74	- 5.78
0667155S	354666.91	-26.34	-12.65
0767185S	405737.77	-26.83	-14.63
0767147S	393753.52	- 8.20	- 3.55
0767155S	262968.65	- 3.55	- 0.65
0767159S	119514.01	- 8.65	- 0.15
0767165S	306051.81	- 9.55	- 0.66
0967049S	219288.95	- 1.24	3.76

base, and an "S" indicates it was a sand asphalt base.

The results of these predictions are, at first glance, disappointing; nearly half of the results miss their mark by percentages exceeding 5%. Further examination suggests the results are not unexpected. In Regression III it was found that, for the asphalt projects, the engineer's estimate is necessary to reflect the job difficulties associated with the project as well as those items not included in the regression equation. Thus, the regression estimate is sensitive to the engineer's estimate. When the engineer's estimate is off by over 20%, it is not surprising that the regression estimate will also miss by an unusually large amount. Even so, for these projects, the regression estimate is generally over twice as accurate, i.e., misses the mark by less than half as much. The results in Table XXIII do indicate, however, that when the highway engineer does provide a reasonable estimate, 10% or less, the regression estimate is quite accurate. Thus, it can be concluded that the regression estimate is doing a reasonably satisfactory job.

Minimum Variance

While performing the stepwise regression analyses, it was realized that the equation resulting from any particular analysis was not necessarily the "best" in terms of the dependent variable having a minimum variance. The cause of this lack of optimization can be explained by considering

the criteria the stepwise procedure uses to select new variables.

The criteria used to pick a new variable as explained by Draper and Smith (8) at the n^{th} step in the analysis (except when n = 1) is to pick the one having the highest partial correlation with the dependent variable. Suppose after n - 1 steps, $Y = f(x_1, x_2, \ldots, x_i)$. A new variable, Y*, is defined as follows:

$$Y^* = Y - Y \tag{3.4}$$

In other words, Y* is the residual remaining after n - 1 steps. For the selection procedure, each of the candidate variables is considered as the dependent variable for a regression equation having as independent variables those which calculate Y. A new variable is constructed for each candidate as follows:

$$X_j^* = X_j - X_j \tag{3.5}$$

where

$$X_j = f_j(X_1, X_2, \ldots, X_i)$$

The correlation between Y* and X_j^* is the partial correlation between these two variables, that is, the correlation between Y and X_j after the effects of variables $X_1 \ldots, X_i$ have been removed from both.

The important consideration is the pattern of variation, Y*, after each step of the process. It will be

different, and dependent on which of the candidate variables is chosen to enter the regression equation, that is, Y* will differ depending on whether X_j or X_k is chosen. If X_j was chosen because it had the highest partial correlation for the n^{th} step, Y* may not significantly correlate with any of the remaining candidate variables. However, had X_j been deleted from consideration, the variable having the next highest partial correlation, say X_k, would have been chosen. The Y* resulting from this selection would have had a different pattern and could significantly correlate with a new variable on the succeeding step, and on the next, etc. The variance of Y after the latter process could be much smaller than that for the former one.

Several of the input variables were selectively discarded in sequential computer runs during Regressions IV and V to obtain a smaller variance. Some success was attained by this procedure in that the variance was reduced by as much as 30% to the values presented in these sections. Additional reduction may have been possible by continuing, however, it is felt that the additional reduction would have been slight.

CHAPTER IV

THE PROBABILITY OF WINNING

There are two methods of determining the probability of winning, P(x), for a given bid of x, using the results from the regression analysis: first, by assuming that the errors remaining after regression, the residuals, are normally distributed with a constant variance of σ^2, and second, by constructing an empirical distribution from these residuals. Both of these methods will be investigated using the results from Regression IV for illustration.

Assumption of the Normal Distribution

It is first necessary to establish the validity of assuming the normal distribution, i.e., determine whether the degree of agreement between the distribution of the residuals and the normal distribution is satisfactory. This can be done visually in Figure 5; the histogram represents the distribution of the residuals and the smooth curve, that of a normal distribution with mean = 0 and variance = 1169 x 10^5. The variance was taken from the Regression IV AOV Table XV.

The Kolmogorov-Smirnov One-Sample Test was used to determine quantitatively if it is reasonable to believe that

the residuals resulting from Regression IV could have come from a normal distribution (9). This test involves the comparison between the cumulative frequency distributions of the observed and that of the theoretical. The magnitude of the maximum divergence between these two is determined, and reference to a sampling distribution establishes whether a divergence that large could have occurred by chance.

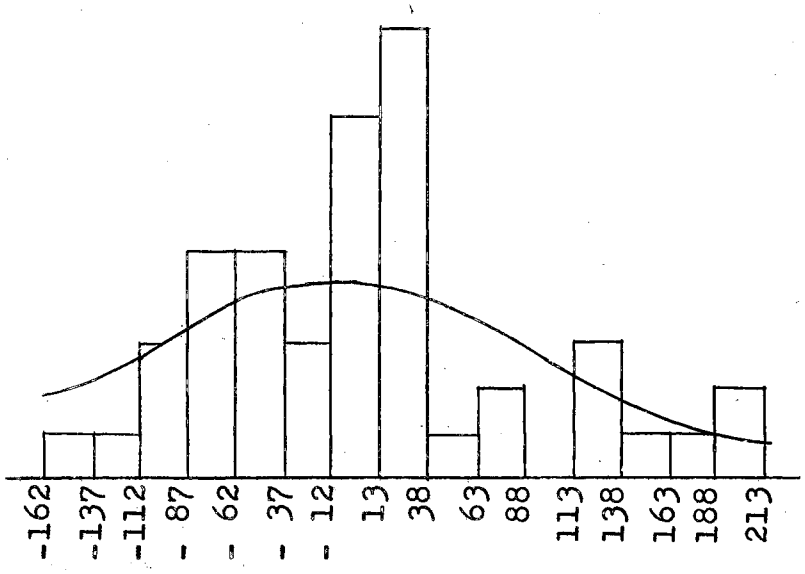

Figure 5. Distribution of the residuals (10^{-2}) from Regression IV.

With 46 observations, a divergence of 0.180 or larger will occur about 10% of the time through chance. Since a maximum divergence of only 0.148 occurred in this test, Table XXIV, it is not unreasonable to assume that the residuals are normally distributed. It should be noted that

TABLE XXIV

KOLMOGOROV-SMIRNOV ONE SAMPLE TEST

Range	Observed Freq	Cum	Prob	Normal z	Prob	Absolute Difference
-162>x≤-137	1	1	0.022	-1.27	0.102	0.080
-137>x≤-112	1	2	0.044	-1.04	0.149	0.105
-112>x≤- 87	3	5	0.108	-0.805	0.209	0.101
- 87>x≤- 62	5	10	0.216	-0.575	0.281	0.065
- 62>x≤- 37	5	15	0.324	-0.343	0.367	0.043
- 37>x≤- 12	3	18	0.391	-0.111	0.456	0.065
- 12>x≤ 13	8	26	0.565	0.121	0.548	0.018
13>x≤ 38	10	36	0.785	0.352	0.637	0.148
38>x≤ 63	1	37	0.805	0.582	0.719	0.086
63>x≤ 88	2	39	0.850	0.815	0.794	0.056
88>x≤ 113	0	39	0.850	1.04	0.851	0.001
113>x≤ 138	3	42	0.905	1.28	0.890	0.005
138>x≤ 163	1	43	0.935	1.51	0.935	0.000
163>x≤ 188	1	44	0.957	1.74	0.959	0.002
188>x≤ 213	2	46	1.000	1.97	0.983	0.017

Maximum Absolute Difference = 0.148

since σ^2 was estimated from the observed distribution, the theoretical distribution of the absolute difference between the two cumulative frequency distributions is not exactly known. However, in this situation the Kolmogorov-Smirnov Test will be a conservative one, i.e., the α level may be smaller than 0.10.

For a particular project, the distribution about the regression estimate, RE, will be interpreted as the distribution of the bid of the lowest competitor (low bid in this study) having a mean of RE and a standard deviation of $[\$1169 \times 10^5]^{1/2} = \$10812$. Thus, the probability of winning, P(x), with a given bid of x, will be the area under the normal curve from x to infinity. The shaded area in Figure 6 represents this probability.

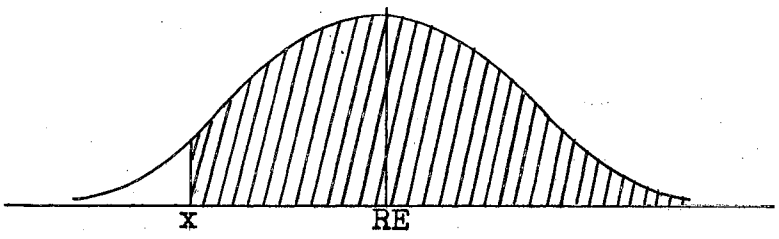

Figure 6. Probability of winning

For example, suppose a contractor using this model estimates the mean bid of his lowest competitor, RE, to be $900,000 with the regression equation. Again, all the

information needed to make this estimate is extracted from the "Notice to Contractors." He wishes to know the probability of winning the project with a bid of $889,187. First, the standard normal deviate, z, must be found.

$$z = (X-RE)/\sigma = (\$889187 - \$900000)/\$10812 = -1$$

From a table of the normal distribution

$$P(x) = P(z^* \geq -1) = 0.8413$$

That is, the probability he will win the project with a bid of $889,187 is 0.8413. His expected profit from this bid can be calculated if the project cost were known. Suppose his estimated cost, C, is $828,000 (92% of RE), then

$$E(x) = P(x) \cdot [x-C] = 0.8413\ [\$889187 - \$828000] = \$51477$$

To find the optimum bid for this project, i.e., the one which maximizes the expected profit, it is necessary to calculate the expected profit for all reasonable bid values. Generally, it is not necessary to calculate E(x) for values of x less than C, because a project won with this bid would likely result in a monetary loss to the contractor. The values of E(x) have been calculated for this example and are shown in Figure 7, along with the associated values of P(x), taken from a table of the normal distribution. It is quickly seen from this Figure that the optimum bid is about $885,000, has a probability of winning of 0.9177, and an expected profit of $52,200. If the project is won, it will

net him 6.9% profit ($57000), based on his expected cost.

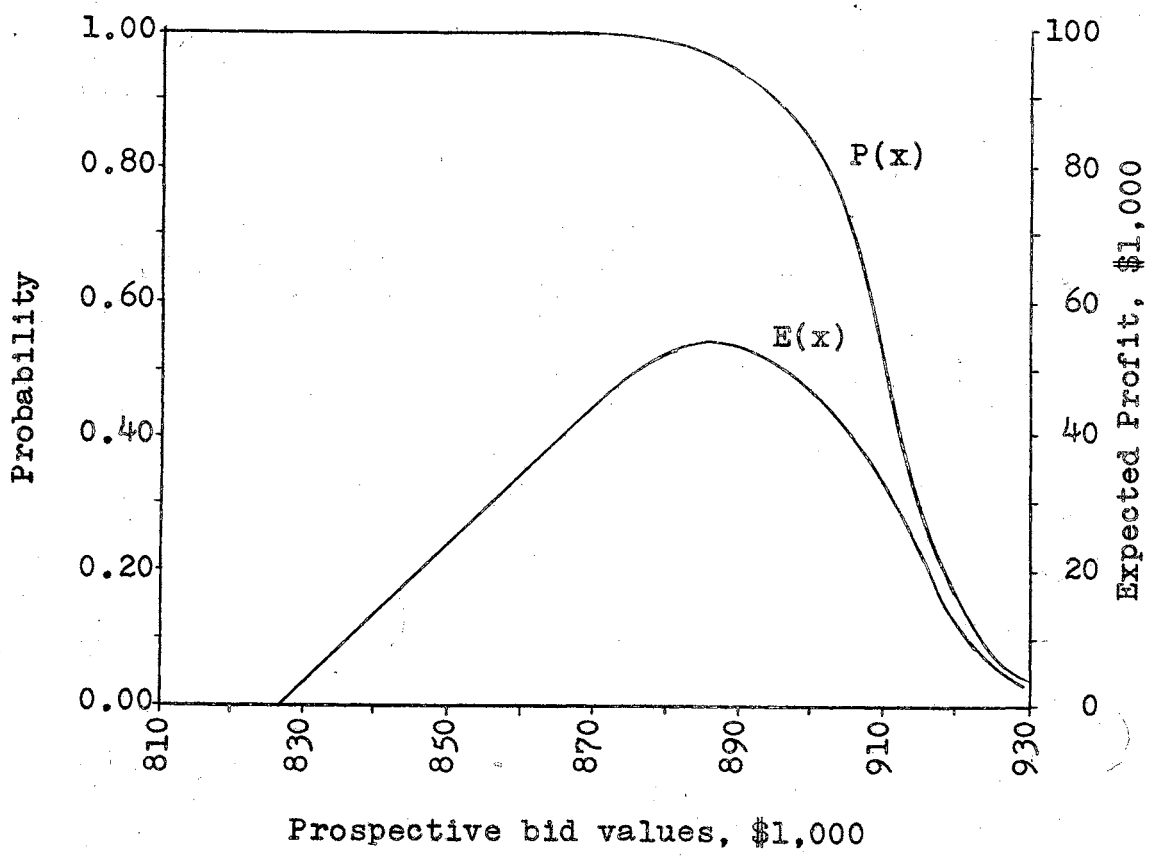

Figure 7. Expected Profit Using Normal Assumptions

An Empirical Distribution

If it is not assumed that the residuals are normally distributed, than an empirical distribution can be constructed using the percent deviations between the actual low bid, LB, and the regression estimate, RE. These percentages are based on the regression estimate, that is,

$$P' = [(LB-RE)/RE] \cdot 100\% \qquad (4.1)$$

A new variable P* was generated by subtracting each P' from 100%. The result of this operation is twofold. First, the center of the distribution has been moved from zero to 100%, and second, overestimates will be represented by values exceeding 100%. For example, if the regression equation overestimated the low bid by 2%, then P, from Equation (4.1), is -2%. The new variable, P*, will be 102%.

$$P^* = 100\% - P' = 100\% - (-2\%) = 102\%$$

Conversely, an underestimate of 2% will be represented by P* as 98%.

P* was calculated for each project and a histogram drawn to represent the density function of the empirical distribution. The density function is shown in Figure 8; the cumulative function is shown in Figure 9. A smooth curve has been drawn through the points in Figure 9 because it is reasonable to suppose that the P* distribution is a continuous one.

The empirical distribution is analogus to the distribution of the residuals developed in the previous section in that it represents the variability of the percent errors about the estimated value, RE. A probability value read from Figure 9, say P(x), is interpreted as the probability that the bid of the lowest competitor will be equal to or greater than x. For example, if x = 98.8%, i.e., the bid contemplated is 98.8% of the regression estimate, then the

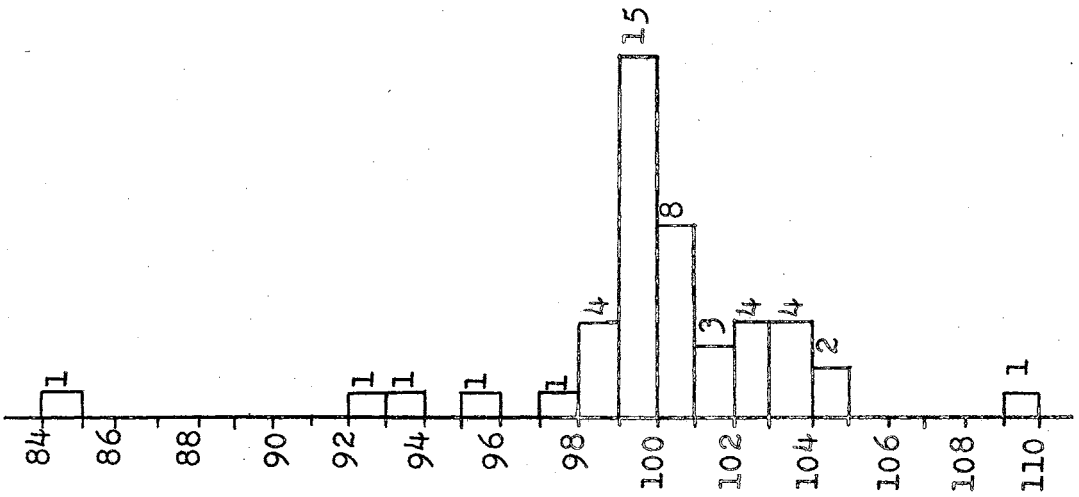

Figure 8. Distribution of the Percent Deviations

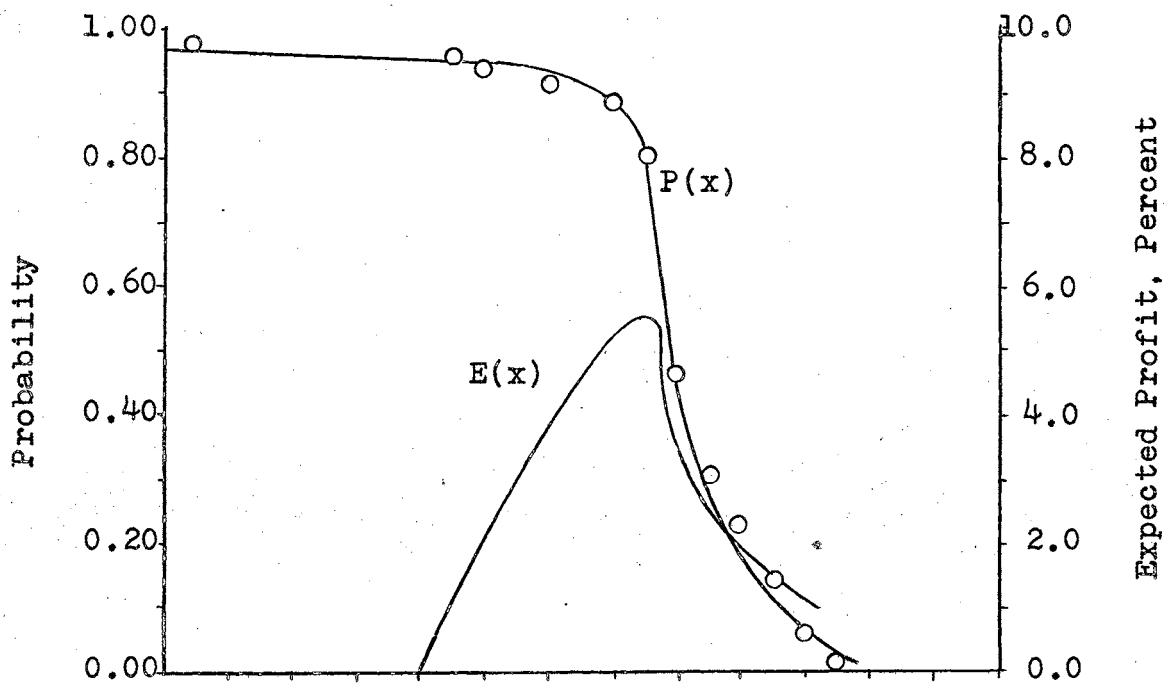

Figure 9. Cumulative Distribution and Expected Profit

probability is 0.82 that the bid of the lowest competitor is equal to or greater than this amount. Thus, P(x) is interpreted as the probability of winning.

The expected profit resulting from a bid of x will be in terms of a percentage of the regression estimate. Both C, the project cost and x, the bid value, are expressed as a percentage of RE, and, as before,

$$E(x) = P(x)[x-C]$$

The optimum bid is found by calculating all values of E(x) for a given project cost, C. The values have been calculated for the case where the project cost 92% of the regression estimate and are plotted on Figure 9. By inspection, the optimum bid will be about 5.6%. If the RE were $900,000, as in the previous example, then the project cost, optimum bid, and expected profit are respectively,

$$C = .92(\$900000) = \$828000$$
$$x = .988(\$900000) = \$889200$$
$$E(x) = .056(\$900000) = \$50400$$

The difference between these and the values obtained by assuming the normal distribution are ascribed to differences in the shapes of the two cumulative curves.

The Optimum Bid

With both distributions, it is possible to determine the optimum bid as a function of the project cost without

relating it to the magnitude of the regression estimate. In the first distribution, in which normality was assumed, this is a result of assuming a constant variance for all values of the RE. The shape of the probability curve is the same for all values, but it is translated laterally depending on the magnitude of the estimate. By expressing both the project cost and contemplated bid in terms of the number of standard deviations from the RE, the optimum bid may be determined.

For example, suppose that the project cost is RE - $N\sigma$ and the contemplated bid is RE - $k\sigma$ less than the regression estimate, where N and k are constants, $N \geq k$. The profit from the bid is

$$\text{Profit} = [RE - k\sigma] - [RE - N\sigma] = (N - k)\sigma$$

The probability of winning is related to k and is found from tables of the normal distribution.

$$P(x) = P(z \geq - k)$$

The expected profit is found from the above to be

$$E(x) = P(x) \cdot [(N - k)\sigma]$$

By fixing the value of N, and varying k, the optimum bid may be determined. This has been done for selected values of N and graphed in Figure 10. If, for example, a regression estimate is \$1,000,000 and the project cost estimated to be \$919,000, the optimum bid is found quickly from

the following procedure.

$$N = (\$1000000 - \$919000)/\$10800 = 7.5$$

From Figure 10, for N = 7.5, k = 1.4. Hence, the optimum bid, x, is

$$x = \$1000000 - 1.4\ (\$10800) = \$984900.$$

After consulting the table of the normal distribution, the probability of winning, P(x), and the expected profit, E(x), are found respectively to be

$$P(x) = P(z \geq -1.4) = 0.919$$

$$E(x) = 0.919\ (\$984900 - \$919000) = \$60562.$$

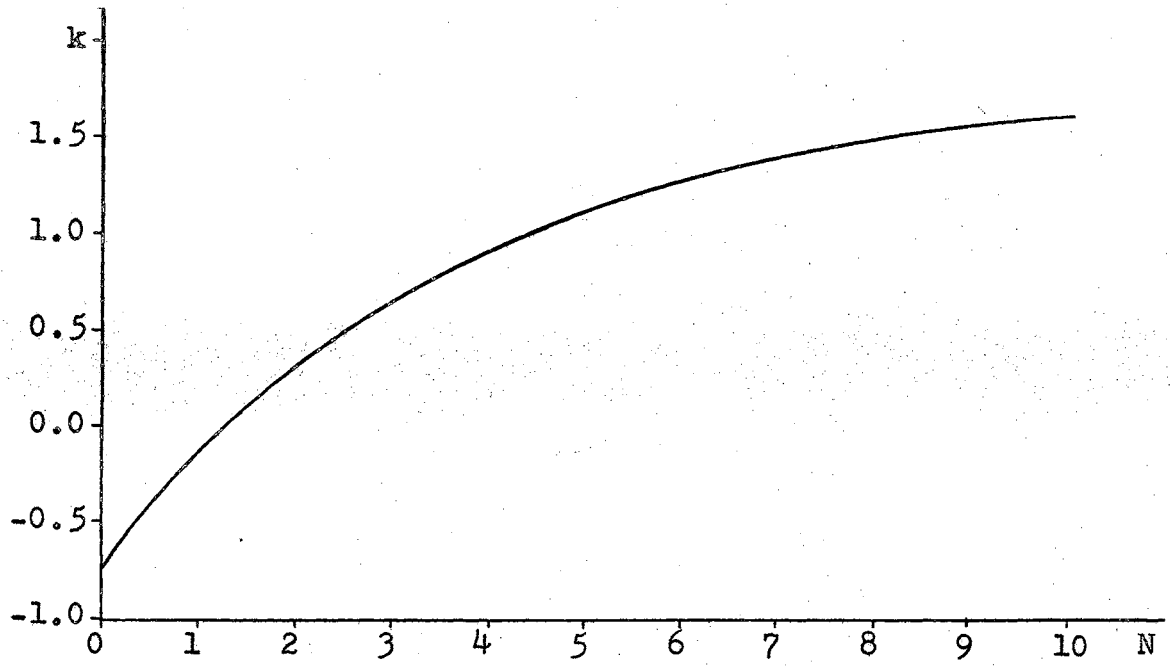

Figure 10. Values of N and k for Finding Optimum Bids

The empirical distribution is "corrected" for the size of the regression estimate. Irregardless of its size, the probability distribution in Figure 9 will remain the same. Since both the project cost, C, and bid, x, are expressed as a percent of the RE, the profit from the bid, also expressed as a percentage, is obtained by subtracting the two.

$$\text{Profit} = x - C$$

The probability of winning, P(x), is obtained, as before, by entering Figure 9 at the value of x. The expected profit, E(x), is then

$$E(x) = P(x)\,[x - C]$$

By varying the value of x for a given C, the maximum E(x) is found.

The expected profit has been calculated for all reasonable bid values in increments of 1% for selected values of C. The results of these calculations are given in Appendix D. The optimum bid and its associated expected profit have been extracted from this appendix and is listed in Table XXV. Thus, for a project whose cost is 87% of the RE, the optimum bid is 99%, and the probability of winning is 0.820. It is also apparent from this table that if the contractor requires at least 6% profit, based on his cost, he can not make an optimum bid on projects whose costs are more than 93% of the regression estimate.

TABLE XXV

OPTIMUM BIDS

Cost Percent	Optimum Bid Percent	P(x)	Expected Profit	Profit Based on C
84	97	.920	11.960	15.5
85	98	.880	11.440	15.3
86	99	.820	10.660	15.2
87	99	.820	9.840	13.8
88	99	.820	9.020	12.5
89	99	.820	8.200	11.2
90	99	.820	7.380	10.0
91	99	.820	6.560	8.8
92	99	.820	5.740	7.6
93	99	.820	4.920	6.5
94	99	.820	4.100	5.3
95	99	.820	3.280	4.2
96	99	.820	2.460	3.1
97	99	.820	1.640	2.1
98	100	.440	0.880	2.0
99	102	.200	0.600	3.0
100	102	.200	0.400	2.0

Multiproject Strategies

Situations often arise in which the contractor wants to bid on more than one project being offered on a particular letting date. Indeed, the number of projects bid by each contractor each month of 1964 was counted, and the results show that this number can go as high as 14. The complete results of this count are shown in Figure 11. The contractor may not desire to win all the projects he bids for in these situations; to win them all could overextend his capabilities both in financing the projects and in performing the work requirements. To avoid this condition, he could bid higher than optimum value so as to reduce the probability of winning them to an acceptable level. This is a desirable strategy because he would make more profit on the projects that he did win. The problem then is to maximize his overall profit from all the bids, yet bidding in such a manner as to satisfy a restriction which prevents him from overextending himself.

The restrictions constraining the contractor may take a variety of different forms. Among these are:

The total value of work in progress plus new bids must be equal to or less than M

The probability of winning more than N new projects must be equal to or less than P_N

The probability of winning more than L dollars in new projects must be equal to or less than P_L

The expected value of the new work must be equal to or less than T.

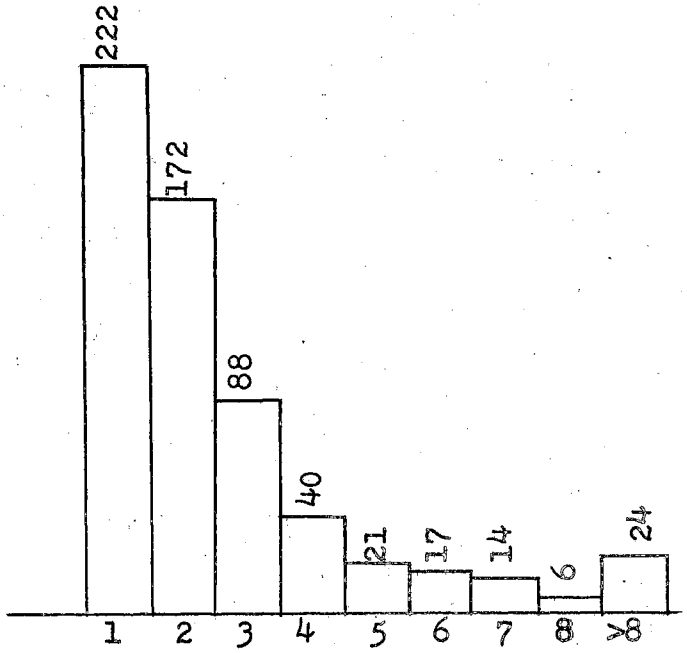

Figure 11. Number of Bids Submitted in a Monthly Letting.

To illustrate how a contractor could fully utilize a multiproject strategy to increase his profit, the last restriction will be more fully investigated. Suppose that for a particular letting, a contractor finds four projects suited to his particular specialization. He wishes to bid on all, maximizing his overall expected profit from the bids, yet requiring that the expected value of the new work be less than one million dollars.

$$\text{Maximize} \sum_{i=1}^{4} P(x_i) \cdot (X_i - C_i)$$

$$\text{Subject to} \sum_{i=1}^{4} x_i \cdot P(x_i) \leq \$1000000$$

Using the regression estimate, the project costs expressed as a percent of the RE, and probability values taken from the empirical probability distribution, Figure 9, all as input information, a computer program evaluated all possible combinations to determine the correct value for the bids. To simplify the calculations, only ten possible bids were considered for each project, including the "no-bid" possibility. The initial information, and results are given in Table XXVI.

TABLE XXVI

MULTIPROJECT BID STRATEGY

Project	RE	C	Bid	P(x)	$x_i \cdot P(x)$	E(x)
1	495	91.0%	495	0.44	217.80	19.80
2	647	88.0	640	0.82	523.52	60.22
3	670	94.5	690	0.13	89.97	7.42
4	510	92.0	515	0.31	159.50	14.50
				Totals	990.79	101.94

It should be noted in this table, there was only one project, project 2, for which the optimum bid was made. In the other three, the bids were higher than optimum,

decreasing the value of P(x), but increasing the contractor's profit if they are won. Had there been additional projects, say six altogether, it is likely that the probability of winning the individual projects would have been reduced even further, giving the contractor additional profit on those won.

The contractor, when analyzing these results might be interested in the probability of winning at least one project, or at least two projects, etc., or the probability of winning at least L dollars in new work. This information is obtained by evaluating the sixteen possible outcomes of the letting for the contractor. In general, there will be 2^n possible outcomes, where n is the number of projects. Table XXVII lists the sixteen possible results for the example problem. An L indicates the project was lost while a W indicates it was won.

The cumulative column in Table XXVII gives the probability of winning the indicated amount of new work or more. For example, the probability of winning $1,010,000 or more of new work is 0.5800. By adding the probabilities of all outcomes in which only one project was won, the probability of winning exactly one project is determined. This probability is 0.3595. Similarly, the probabilities of winning exactly two, three or all projects are found to be respectively, 0.4144, 0.1511, and 0.0145. From these results, other probabilities of interest to the contractor can be determined. For example, the probability of winning at

TABLE XXVII

BIDDING RESULTS

Project 1 2 3 4	Probability	Cumulative	Value of New Work (in $1000)
L L L L	0.0605	1.0000	0
W L L L	0.0475	0.9395	495
L L L W	0.0271	0.8920	515
L W L L	0.2759	0.8649	640
L L W L	0.0090	0.5890	690
W L L W	0.0213	0.5800	1010
W W L L	0.2169	0.5587	1135
L W L W	0.1239	0.3418	1155
W L W L	0.0070	0.2179	1185
L L W W	0.0040	0.2109	1205
L W W L	0.0413	0.2069	1330
W W L W	0.0973	0.1656	1650
W L W W	0.0031	0.0683	1700
W W W L	0.0323	0.0652	1825
L W W W	0.0184	0.0329	1845
W W W W	0.0145	0.0145	2340

most two new projects is found by adding the probabilities for 0, 1, and 2 new projects.

$$0.0605 + 0.3595 + 0.4144 = 0.8344$$

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

General Remarks and Conclusions

The problem of determining an optimum bid for a property right or for the performance of a service has been investigated by several people. Three, related to the highway construction industry, were studied in detail. All were found to be deficient when their application to this industry was considered. The first model, in which the contractor needs to keep a file on the bids of all possible competitors, relating them to his own cost estimates, was found to be infeasible due to the lack of a sufficient amount of data. In the second, in which a regression analysis was performed on the spread between the two lowest bidders, it was found that the bid was optimized only in that situation in which the contractor was already the low bidder. No attempt was made to optimize his overall bid value or to estimate the likelihood that a bid of a given size would win. The third, involving the introspection of the contractor's own bidding trend, was discredited because it failed to consider the relative suitability of the contractor's organization to the various types of projects.

The model developed in this dissertation avoids each

of the three problems noted above. First, it was developed from data from sources readily available to all contractors, the bid tabulation books. By means of a regression analysis, relating magnitude of the work items to the low bid for the project, it was shown to be possible, in Regression V, to estimate the bid value of the low bidder within 3% of the actual value 75% of the time. It should be noted that the identity of the low bidder was not used so that this model, as compared to Friedman's Competitor model, is independent of this classification.

Second, from the results of the regression analysis, either by assuming the residuals were normally distributed or by developing an empirical distribution, it was shown that P(x), the probability of winning the bid as a function of the bid value, could be evaluated. After estimating, independently, the cost of the project to the contractor, the optimum bid, maximizing the expected profit, was easily found. Thus, the contractor using this model, as compared to Gates' Least Spread Theory, determines his overall optimum bid value, not just the optimum bid <u>given</u> he is the low bidder.

Third, because the project cost is estimated independently of the distribution for P(x), the contractor may evaluate his relative suitability to each project, and bid accordingly. If he is well suited, then his bid, including a reasonable amount for profit, will have a high probability of winning. He may even be able to increase his bid, and

consequently his profit, without greatly reducing this probability. On the other hand, if he is not well suited, this fact will become evident from a low probability of winning. In either case, the contractor using this model, as compared to Gates' Introspection Approach, will have flexibility in adjusting the bid values to individual projects according to their relative suitability to his organization.

The only other estimate of the low bid readily available to which the results of the model could be compared was the Highway Engineer's estimate of the project cost. The method of comparison was the mean squared error (MSE) which takes into consideration both the bias and the variance of the estimates. It was found that the MSE for the engineer's estimates was much higher, seven times, than that for the regression estimates. On this basis, the regression estimates were judged the better of the two.

Two distributions were developed from the results of the regression analysis, each being interpreted as the distribution of the bid value of the lowest bidder. In the first, the residuals from the regression analysis were assumed to be normally distributed with mean zero and variance σ^2. The value of σ^2 was taken to be the standard error of the residuals after regression. This assumption was tested by comparing the actual distribution of the residuals to that which would be theoretically expected from a normal distribution. It was found that deviations between the two distributions could have occured by chance. The second,

empirical, distribution was developed by converting the residuals to percent errors.

By using either distribution, it was shown that the optimum bid for a project could be quickly determined by reference to a chart or table. These aids were developed without relating them to the magnitude of a particular regression estimate. The contractor, to find the optimum bid after the project cost has been estimated, needs only to calculate one index number to enter the chart or table. The optimum bid results from one additional calculation. There is no need to calculate all values of the expected profit, E(x), to find the maximum.

Finally, it was noted that a contractor can make more profit by bidding on more projects than he desires to win. The bids submitted are larger than the individual optimums, reducing the probability of winning each, so that in the long run, the desired number of projects are won. A procedure for utilizing this strategy was demonstrated through an example problem.

One point which must be remembered by a contractor contemplating using this model is that it requires continual updating, monthly if possible, yearly at least. There are two reasons for this. First, the construction industry is a dynamic one, continually changing, causing the regression equations to become outdated. These changes are brought about by the utilization of new or improved construction methods and equipment, improved construction materials, and

the expansion of large firms into the market. Second, while for the most part, time was not found to be a significant factor in the analyses, increasing costs of material and labor over time are bound to adversely effect the accuracy and precision of the estimate.

In the development of this model for use by a contractor, some other procedure, such as the backward regression method should be considered to replace the stepwise regression procedure to prevent the necessity of selectively eliminating the input variables. The backward regression procedure is similar to the stepwise regression procedure except that the first step calculates a regression equation involving all of the input variables. At each step thereafter, the least significant variable is deleted and a new regression equation calculated. The process continues until the significance of the least significant variable exceeds a predetermined level. This procedure has one disadvantage when compared with that used in this study; the number of variables must be at most one less than the number of observations whereas any number of candidate variables may be considered in the stepwise procedure. This, however, should pose no handicap because, as can be seen in Table IV of Chapter II, the number of work items used consistently in the various project types is severely limited. The number of work items considered for each project type would normally be expected to be less than the number of observations.

Proposal For Future Investigation

A weak point in this model, and in the others which have been developed, is the explicit assumption that the project cost to the contractor is deterministic and known. If a model could be developed, presumably by regression analysis, which would estimate the project cost using the same sources of information as that to predict the bid of the lowest competitor, the contractor could pick and choose among the offerings only those projects most profitable to him. He could then concentrate all his energies and talents in developing the bid for these few, rather than making cost estimates for many projects before picking from these, the ones which appear most profitable. The study proposed here would be a prerequisite for any contractor before full and efficient use could be made of the model developed in this dissertation.

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APPENDIXES

FOREWORD

Appendix A contains the raw data taken from the bid tabulation books which were used to develop the regression models. The Item numbers are the Highway Code numbers for the variables and are defined in the 1966 edition of Standard Specification Bid Items, a publication of the Oklahoma Highway Department.

Appendix B contains three pages extracted from a "Notice to Contractors."

Appendix C contains the results of the five regression analyses of Chapter III. ENG EST is the actual dollar value of the Highway Engineer's Estimate while EE is the percentage by which this estimate differs from the actual dollar value of the LOW BID. REG EST is the value of the LOW BID estimated by the regression equation while RE is the percentage difference between these two values.

Appendix D contains, in the body of the table, the calculated values of the expected profit expressed as a percentage of the regression estimate. The values for Table XXV of Chapter IV were extracted from this Appendix.

APPENDIX A

A LISTING OF THE WORK ITEMS INCLUDED IN EACH PROJECT AND THEIR MAGNITUDES

PROJECT 0264023
LENGTH 1.057

LOW BID 352495.91
ENG EST 368793.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	500.00	104	9734.00	119	17859.00
130	72696.00	141	34561.00	149	9316.00
157	9316.00	161	60.00	204	25805.00
205	6225.00	206	135.00	207	121.00
236	7485.00	238	3605.00	240	624.00
241	11300.00	250	8563.00	263	226.00
275	183.00	302	1445.00	430	6248.00
447	9963.00	448	162.00	444	11633.00
457	281.00	465	162.00	467	2181.00
477	24.00	501	275.00	502	22.00
712	2400.00	857	376.00	858	2.00
859	2.00	172	21034.00	173	934.00
732	20523.00	740	1.28	735	308.00
766	15.00	570	375.00	572	125.00
574	150.00				

PROJECT 0264029
LENGTH 6.421

LOW BID 1111918.50
ENG EST 1242731.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	5000.00	104	16013.00	119	70320.00
130	387204.00	204	128072.00	205	81756.00
206	1807.00	207	1566.00	236	28403.00
238	13840.00	240	2378.00	241	56746.00
250	9645.00	302	6079.00	447	317.00
448	900.00	275	56.00	704	200.00
715	1065.00	724	600.00	168	41029.00
166	443.00	172	119241.00	173	5292.00
570	2300.00	572	700.00	574	920.00

PROJECT 0264035
LENGTH 7.065

LOW BID 1207121.90
ENG EST 1313944.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	6000.00	104	114215.00	119	48548.00
130	494893.00	207	1758.00	236	31593.00
238	15393.00	241	62371.00	250	9753.00
259	1996.00	447	940.00	857	700.00
574	800.00	724	950.00	444	1801.00
240	2645.00	176	45.00	204	141135.00
205	92332.00	206	2051.00	172	126965.00
173	5636.00	570	2000.00	572	750.00

PROJECT 0264017
LENGTH 1.459

LOW BID 500591.44
ENG EST 533163.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	18444.00	119	23269.00	130	105345.00

141	55857.00	149	15046.00	157	15046.00
161	102.00	204	37035.00	205	9974.00
206	220.00	207	189.00	236	9801.00
238	4835.00	240	824.00	241	14994.00
250	13679.00	263	1587.00	275	706.00
302	244.00	430	9420.00	444	11785.00
448	11130.00	457	235.00	467	824.00
477	7.00	501	415.00	502	35.00
712	12275.00	857	249.00	570	375.00
572	125.00	732	12944.00	740	.80
735	194.00	766	8.00	172	28883.00
173	1283.00	574	150.00	278	5.00

PROJECT 0364005
LENGTH .467

LOW BID 181914.33
ENG EST 184056.22

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	1000.00	104	11049.00	119	5742.00
130	46168.00	141	43544.00	149	12850.00
157	12850.00	161	82.00	204	13164.00
205	6318.00	206	139.00	207	124.00
236	2454.00	238	1089.00	240	203.00
241	4423.00	250	10781.00	263	1568.00
430	777.00	447	230.00	448	450.00
465	183.00	712	2650.00	172	10859.00
173	483.00	570	700.00	572	300.00
574	280.00	575	500.00		

PROJECT 0464015
LENGTH 6.547

LOW BID 1048058.90
ENG EST 1197934.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	21800.00	104	17257.00	119	68050.00
130	431488.00	176	83.00	204	131660.00
205	83425.00	206	1857.00	207	1608.00
236	29143.00	238	14199.00	240	2440.00
241	57537.00	250	12170.00	249	2927.00
447	2872.00	448	900.00	715	602.00
726	2.00	168	7233.00	166	104.00
172	121422.00	173	5392.00	570	3000.00
572	1000.00	574	1200.00	738	2.00
105	63035.00				

PROJECT 0464023
LENGTH 7.276

LOW BID 1466789.30
ENG EST 1583026.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	5000.00	104	23825.00	119	97660.00
130	554941.00	176	94.00	204	157454.00
205	95913.00	206	2124.00	207	1838.00
236	33026.00	238	18531.00	240	2924.00

241	69051.00	250	11195.00	249	2672.00
278	14.00	447	4088.00	448	6550.00
674	1520.00	168	2178.00	166	24.00
172	140664.00	173	6255.00	570	3000.00
572	1000.00	574	1200.00	678	5.00

PROJECT 0464071 LOW BID 105410.34
LENGTH 2.547 ENG EST 122631.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
129	134.49	176	100.00	217	5674.00
219	228.00	222	4.00	223	11.00
172	18089.00	173	803.00	241	7439.00
275	17.00	470	89.00	766	15.00
767	45.00	102	500.00	712	500.00
204	20380.00	238	2580.00	240	165.00
570	500.00	574	200.00		

PROJECT 0564033 LOW BID 957869.33
LENGTH 6.771 ENG EST 1110232.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	3000.00	104	29068.00	130	387901.00
204	132297.00	205	84850.00	206	1877.00
207	1624.00	236	30182.00	238	14705.00
240	2528.00	241	42842.00	250	10290.00
176	300.00	447	1904.00	448	900.00
172	117300.00	173	5527.00	570	3000.00
572	1000.00	574	1200.00		

PROJECT 0564037 LOW BID 1017401.40
LENGTH 6.964 ENG EST 1218568.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	3000.00	176	300.00	130	421660.00
204	144245.00	205	91621.00	206	2017.00
207	1764.00	236	31272.00	238	15237.00
240	2618.00	241	45511.00	250	19437.00
249	3945.00	447	3444.00	448	1844.00
172	125334.00	173	5906.00	570	3000.00
572	1000.00	574	1200.00		

PROJECT 0764011 LOW BID 1134814.60
LENGTH 5.800 ENG EST 1155743.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	5591.00	104	101725.00	119	16725.00
130	380666.00	176	300.00	204	129850.00
205	82403.00	206	1831.00	207	1569.00
236	26552.00	238	14074.00	240	2295.00

172	123355.00	173	5812.00	241	44543.00
250	17223.00	263	1207.00	430	1380.00
862	144.00	447	150.00	448	586.00
479	61.00	501	52.00	502	10.00
503	4.00	673	1621.00	678	9.00
570	2100.00	572	700.00	574	840.00
278	7.00	861	900.00	729	50.00

PROJECT 0864089
LENGTH 4.667
LOW BID 248715.53
ENG EST 277940.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	1000.00	119	20356.00	130	103741.00
176	175.00	204	36824.00	217	10214.00
219	411.00	222	6.00	223	21.00
238	4699.00	240	300.00	241	9137.00
172	28020.00	173	1329.00	168	29337.00
166	317.00	570	750.00	572	250.00
574	300.00	766	8.00		

PROJECT 0864083
LENGTH 4.159
LOW BID 248866.79
ENG EST 278598.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	1000.00	119	18234.00	130	76714.00
176	268.00	204	33100.00	217	9255.00
219	371.00	222	6.00	223	19.00
238	4186.00	240	267.00	241	8183.00
712	1150.00	172	27916.00	173	1315.00
168	42334.00	166	457.00	570	750.00
572	250.00	574	300.00	767	58.00
766	1.00				

PROJECT 0964071
LENGTH 6.014
LOW BID 395771.43
ENG EST 423064.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
176	550.00	102	2000.00	104	883.00
118	30734.00	130	187772.00	204	58776.00
217	20475.00	219	836.00	222	13.00
223	42.00	238	8657.00	240	553.00
241	17290.00	172	48574.00	173	2289.00
570	2250.00	572	750.00	574	900.00
712	400.00	766	32.00		

PROJECT 0964013
LENGTH 1.968
LOW BID 476782.47
ENG EST 503935.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	3000.00	118	40059.00	162	2472.00

163	146.00	204	42279.00	205	26881.00
206	597.00	207	517.00	172	42362.00
173	1998.00	236	8814.00	238	4300.00
240	739.00	241	19493.00	250	10456.00
263	872.00	430	756.00	447	300.00
448	750.00	465	211.00	570	1500.00
572	500.00	574	600.00	575	1000.00
168	102898.00	166	1112.00	466	135.00

PROJECT 0964009
LENGTH 5.536
LOW BID 1304253.90
ENG EST 1404357.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	5000.00	118	121175.00	162	10899.00
163	634.00	204	124813.00	205	75924.00
206	1667.00	207	1458.00	236	24801.00
238	12171.00	240	2082.00	241	43724.00
172	104958.00	173	4946.00	250	36809.00
263	402.00	430	4724.00	436	2708.00
466	248.00	465	300.00	168	300175.00
166	3242.00	570	1500.00	572	500.00
574	600.00	766	11.00		

PROJECT 0964005
LENGTH 1.812
LOW BID 210926.13
ENG EST 265778.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	14949.00	119	13581.00	130	65951.00
176	20.00	204	22361.00	205	16823.00
206	358.00	207	329.00	236	4780.00
238	2339.00	240	401.00	241	8163.00
172	20703.00	173	975.00	436	702.00
470	96.00	644	4430.00	712	37.50
767	55.00	766	9.00	570	750.00
572	250.00	574	300.00	278	11.00
729	76.00	735	1.10	738	2.90

PROJECT 1264067
LENGTH 4.521
LOW BID 366978.72
ENG EST 457712.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	12343.00	103	12493.00	115	324.00
129	231.80	176	298.00	204	50612.00
205	43142.00	206	959.00	207	822.00
236	10001.00	238	4991.00	240	845.00
241	18592.00	275	3.00	302	56.00
644	1550.00	650	4274.00	712	375.00
726	4.00	767	77.00	766	23.00
570	500.00	572	170.00	574	200.00
172	50011.00	173	2356.00	738	.60
829	24.00				

PROJECT 0665087
LENGTH 2.894

LOW BID 253423.57
ENG EST 266143.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	22196.00	105	5830.00	130	45100.00
176	155.00	204	29764.00	205	23384.00
206	520.00	207	446.00	236	6395.00
238	3115.00	240	535.00	172	29510.00
173	1390.00	241	10853.00	274	1.00
275	4.00	278	110.00	302	208.00
318	52.00	344	54.00	712	300.00
729	1609.00	730	1304.00	740	.20
735	44.00	738	1.73	168	41169.00
166	501.00	570	750.00	574	300.00
572	250.00	805	1.00		

PROJECT 0864137
LENGTH 4.912

LOW BID 285403.05
ENG EST 302906.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	1047.00	119	19192.00	130	132575.00
164	14358.00	176	265.00	205	35868.00
206	798.00	207	684.00	238	6998.00
240	447.00	259	852.00	275	1.00
278	350.00	470	70.00	712	450.00
570	375.00	572	125.00	574	150.00
729	1604.00	740	.10	735	32.00
766	8.00	162	33032.00	163	1922.00
204	47685.00				

PROJECT 0864129
LENGTH 4.390

LOW BID 285806.93
ENG EST 290502.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	3599.00	105	750.00	119	18077.00
130	114091.00	164	12631.00	176	215.00
205	31451.00	206	699.00	207	600.00
238	6152.00	240	393.00	249	4109.00
275	33.00	278	324.00	302	2470.00
317	36.00	430	1139.00	457	85.00
462	108.00	463	105.00	501	64.00
502	5.00	654	81.00	712	925.00
858	2.00	859	2.00	570	375.00
572	125.00	574	150.00	839	104.00
729	1542.00	740	.10	735	31.00
767	78.00	766	15.00	479	71.00
557	68.00	558	44.00	162	29766.00
163	1732.00	204	43472.00		

PROJECT 0864077
LENGTH 5.334

LOW BID 641346.21
ENG EST 670161.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	111706.00	104	3146.00	105	105700.00
130	89064.00	162	73269.00	163	4264.00
164	36077.00	204	73152.00	176	290.00
205	58835.00	206	1307.00	207	1132.00
236	12195.00	238	5796.00	240	1024.00
250	5381.00	275	50.00	278	629.00
302	3897.00	356	142.00	447	1175.00
448	1516.00	465	133.00	466	59.00
470	187.00	644	2827.00	712	11839.00
715	1960.00	716	1.00	724	1500.00
726	9.00	767	87.00	766	71.00
570	1500.00	572	500.00	574	600.00
729	3285.00	740	.42	735	101.00
738	4.91	168	66604.00	166	719.00
732	3423.00	236	1002.00	238	857.00
240	127.00	130	26067.00		

PROJECT 0165029
LENGTH 5.460

LOW BID 439081.01
ENG EST 462225.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
103	3700.00	119	20754.00	129	262.80
162	57961.00	163	3374.00	164	29372.00
176	475.00	204	59701.00	205	50712.00
206	1127.00	207	966.00	236	12079.00
238	5884.00	240	1012.00	457	176.00
712	1200.00	858	4.00	168	15867.00
166	172.00	766	18.00	570	750.00
572	250.00	574	300.00		

PROJECT 0465079
LENGTH 7.438

LOW BID 610761.50
ENG EST 630348.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	6123.00	103	5100.00	117	13176.00
130	168437.00	162	78627.00	163	4576.00
176	160.00	204	81903.00	205	69019.00
206	1534.00	207	1315.00	236	16191.00
238	7887.00	240	1360.00	241	39964.00
249	3200.00	275	128.00	302	11453.00
430	219.00	465	54.00	470	171.00
644	460.00	712	2400.00	738	1.24
166	918.00	168	75556.00	570	750.00
572	250.00	574	300.00	111	667.00

PROJECT 0765127

LOW BID 430303.99

LENGTH 4.618

ENG EST 452351.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	9097.00	103	8470.00	105	15000.00
117	5448.00	130	72680.00	162	47445.00
163	2778.00	164	23697.00	176	438.00
204	50558.00	205	35711.00	206	787.00
207	677.00	236	10896.00	238	5331.00
240	911.00	249	4716.00	259	978.00
275	103.00	277	21.00	278	332.00
302	8020.00	317	56.00	318	52.00
430	1405.00	462	296.00	463	430.00
654	382.00	666	5.00	667	2.00
726	6.00	729	1271.00	738	1.90
838	1100.00	839	492.00	111	1281.00
168	49096.00	166	596.00	570	750.00
572	250.00	574	300.00	767	31.00
805	1.00				

PROJECT 0765083

LOW BID 51786.22

LENGTH .704

ENG EST 55071.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
130	18829.00	162	7114.00	163	414.00
164	3572.00	176	23.00	204	7308.00
205	5141.00	206	114.00	207	98.00
236	1676.00	238	828.00	240	143.00
275	31.00	302	2513.00	570	200.00
572	100.00	574	80.00	767	37.00

PROJECT 1065059

LOW BID 333967.77

LENGTH 1.644

ENG EST 350378.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	1500.00	117	26159.00	130	121373.00
162	32853.00	163	1912.00	164	14514.00
165	36204.00	176	23.00	205	22144.00
206	491.00	207	421.00	236	7693.00
238	3754.00	240	645.00	249	6231.00
447	2118.00	448	455.00	465	86.00
570	300.00	572	100.00	574	120.00
712	6600.00	766	140.00	768	70.00
769	14.00	805	1.00		

PROJECT 0166043

LOW BID 738348.08

LENGTH 7.786

ENG EST 808884.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	54484.00	105	1300.00	115	1689.00
117	10033.00	162	84791.00	163	4935.00
164	43296.00	166	3479.00	168	255814.00
176	210.00	205	75001.00	206	1667.00

207	1429.00	236	17225.00	238	8391.00
240	1442.00	275	57.00	302	3574.00
570	500.00	572	200.00	574	200.00
704	37.50	759	48.00	805	1.00
866	12336.00	738	1.70	165	86889.00

PROJECT 0266023 LOW BID 352281.11
LENGTH 4.286 ENG EST 391790.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	8474.00	105	2718.00	111	1948.00
130	127114.00	162	46184.00	163	2690.00
164	23192.00	165	48315.00	166	110.00
168	9000.00	205	27665.00	206	616.00
207	532.00	236	10392.00	238	5985.00
240	935.00	275	114.00	278	58.00
302	8207.00	435	296.00	461	10.00
570	900.00	572	300.00	574	360.00
646	1702.00	650	6584.00	715	3856.00
729	122.00	738	3.00	805	1.00
712	2500.00				

PROJECT 0366121 LOW BID 434447.46
LENGTH 7.802 ENG EST 472215.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	500.00	129	412.00	162	72276.00
163	4206.00	164	30957.00	165	76381.00
176	435.00	205	56845.00	206	1264.00
207	1084.00	238	11231.00	240	717.00
570	1500.00	572	500.00	574	600.00
712	1087.00	805	1.00		

PROJECT 0366027 LOW BID 1357665.30
LENGTH 4.583 ENG EST 1397669.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2000.00	104	75790.00	119	50557.00
130	386367.00	162	124500.00	163	7246.00
164	65196.00	165	136777.00	166	548.00
168	47166.00	726	2.00	805	2.00
217	23569.00	218	962.00	236	31035.00
238	22776.00	240	3088.00	250	45352.00
278	90.00	418	4000.00	430	13639.00
318	14671.00	448	1626.00	447	632.00
467	1688.00	570	3000.00	572	1000.00
574	1700.00	575	500.00	715	135.00
275	5.00	302	42.00	819	28.00

PROJECT 0466033
LENGTH 4.829

LOW BID 494391.09
ENG EST 540022.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	36228.00	104	3389.00	103	16249.00
105	8906.00	130	91376.00	162	62833.00
163	3657.00	164	30814.00	165	66281.00
166	729.00	168	59994.00	205	58289.00
206	1295.00	207	1110.00	236	12834.00
238	6254.00	240	1075.00	275	261.00
278	109.00	302	25891.00	317	148.00
570	1000.00	572	250.00	574	400.00
644	7294.00	665	120.00	715	3311.00
729	353.00	805	1.00		

PROJECT 0466041
LENGTH 4.877

LOW BID 376124.63
ENG EST 414738.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	7861.00	103	2908.00	105	700.00
111	3416.00	119	19118.00	130	126995.00
162	46405.00	163	2702.00	164	23664.00
165	47340.00	205	31483.00	206	700.00
207	601.00	236	10789.00	238	5493.00
240	919.00	275	25.00	278	42.00
302	1976.00	317	14.00	570	750.00
572	250.00	574	300.00	644	1810.00
651	9194.00	712	2775.00	715	3054.00
729	338.00	738	4.20	805	1.00
353	172.00				

PROJECT 0466037
LENGTH 6.581

LOW BID 493983.26
ENG EST 569514.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	13712.00	103	11968.00	111	2306.00
130	173755.00	162	66780.00	163	3901.00
164	34094.00	165	70213.00	205	50142.00
206	1116.00	207	959.00	236	16015.00
238	7807.00	240	1343.00	262	36.00
275	31.00	302	2782.00	353	180.00
448	450.00	465	62.00	570	1200.00
572	400.00	574	480.00	651	11294.00
712	9700.00	715	5224.00	729	5572.00
735	111.00	738	3.43	740	.35
770	19.00	805	1.00		

PROJECT 0666131
LENGTH 1.778

LOW BID 147280.88
ENG EST 138461.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	500.00	130	12732.00	162	17680.00

163	1029.00	164	7525.00	165	17559.00
166	419.00	168	34472.00	176	190.00
205	13126.00	206	292.00	207	250.00
238	2561.00	240	164.00	570	1500.00
572	500.00	574	600.00	712	925.00
805	1.00				

PROJECT 0666007
LENGTH 5.524
LOW BID 458302.60
ENG EST 440527.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	7625.00	105	2100.00	111	2379.00
130	167089.00	162	56362.00	163	3281.00
164	28554.00	165	58746.00	205	37318.00
206	830.00	207	711.00	236	14072.00
236	7021.00	240	1189.00	275	9.00
302	550.00	343	64.00	353	56.00
570	750.00	572	250.00	574	300.00
651	5428.00	715	1278.00	738	2.00
644	994.00	805	1.00		

PROJECT 0766101
LENGTH 2.209
LOW BID 185926.17
ENG EST 208131.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	13050.00	103	13035.00	105	1450.00
162	25221.00	163	1468.00	164	12652.00
165	25082.00	166	168.00	168	13867.00
176	268.00	205	22077.00	206	491.00
207	420.00	236	4892.00	238	2382.00
240	409.00	275	3.00	278	207.00
302	84.00	353	64.00	570	500.00
572	125.00	574	200.00	644	1620.00
729	1456.00	805	1.00		

PROJECT 0766091
LENGTH 7.943
LOW BID 742766.84
ENG EST 828864.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	5916.00	104	1367.00	103	23560.00
130	133630.00	162	92974.00	163	5411.00
164	47178.00	165	98225.00	166	1526.00
168	125614.00	176	845.00	205	78821.00
206	1751.00	207	1501.00	236	19885.00
238	9697.00	240	1665.00	275	156.00
278	979.00	302	11113.00	317	268.00
318	124.00	344	40.00	447	3750.00
470	466.00	479	61.00	501	31.00
502	4.00	570	3000.00	572	1000.00
574	1200.00	729	6816.00	732	4981.00
735	177.00	444	339.00	740	.74

805	1.00

PROJECT 0766063
LENGTH 6.548

LOW BID 646332.67
ENG EST 676007.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	14464.00	104	3589.00	103	27345.00
105	5850.00	111	3070.00	162	69261.00
163	4027.00	164	35246.00	165	71645.00
166	2492.00	168	205138.00	176	360.00
205	49572.00	206	1102.00	207	944.00
236	16783.00	238	7871.00	240	1388.00
275	53.00	278	40.00	302	4121.00
559	48.00	319	72.00	343	140.00
345	44.00	447	816.00	448	791.00
470	235.00	506	1.00	570	750.00
574	300.00	572	250.00	644	3567.00
651	2554.00	712	5350.00	715	310.00
740	.60	759	706.00	768	87.00
769	54.00	805	1.00		
724	400.00	729	520.00	738	4.00

PROJECT 0564053
LENGTH 4.677

LOW BID 233918.85
ENG EST 297389.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	3096.00	103	4456.00	113	28670.00
129	247.00	176	408.00	204	53451.00
205	35302.00	206	784.00	207	672.00
236	5236.00	240	334.00	644	40.00
767	49.00	766	25.00	726	121.00
274	3.00	712	2025.00	853	101.80
570	750.00	572	250.00	574	300.00

PROJECT 0864005
LENGTH 6.075

LOW BID 230034.79
ENG EST 277154.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	5930.00	113	20763.00	119	24196.00
129	290.40	176	515.00	204	52613.00
205	27856.00	206	619.00	207	530.00
236	6185.00	240	395.00	275	13.00
302	627.00	558	156.00	863	1633.00
461	3.00	712	1900.00	704	1400.00
726	16.00	735	14.00	730	1110.00
729	205.00	505	2.00	767	13.00
766	43.00	570	750.00	572	250.00
574	300.00	839	308.00	738	.88

PROJECT 0365103
LENGTH 3.587

LOW BID 169166.60
ENG EST 167603.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
103	1531.00	176	235.00	113	18223.00
119	3864.00	130	75728.00	204	32840.00
205	17244.00	206	384.00	207	329.00
238	4762.00	240	304.00	712	1250.00
168	13521.00	166	146.00	570	1500.00
572	500.00	574	600.00		

PROJECT 0666115
LENGTH 2.854

LOW BID 163720.75
ENG EST 123258.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
113	13911.00	129	154.00	204	27341.00
176	145.00	205	13467.00	206	300.00
207	257.00	238	3770.00	240	241.00
570	750.00	572	250.00	574	300.00
712	900.00	805	1.00	104	7500.00

PROJECT 0866121
LENGTH 1.811

LOW BID 97749.49
ENG EST 91545.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
113	8925.00	129	100.00	204	17822.00
176	138.00	205	8371.00	206	186.00
207	159.00	238	2517.00	240	161.00
570	750.00	574	300.00	572	250.00
712	900.00				

PROJECT 0866117
LENGTH 2.854

LOW BID 153262.35
ENG EST 143332.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
113	13911.00	129	154.50	204	27341.00
176	145.00	205	13467.00	206	300.00
207	257.00	238	3770.00	240	241.00
570	750.00	574	300.00	574	250.00
712	900.00	805	1.00	104	7500.00

PROJECT 1066019
LENGTH 5.772

LOW BID 239817.23
ENG EST 245345.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	1200.00	103	1000.00	104	2500.00
113	21181.00	130	70134.00	204	54053.00
166	722.00	168	59456.00	176	250.00
205	27509.00	206	609.00	207	523.00
236	5705.00	240	364.00	570	1500.00
574	600.00	572	500.00	712	1050.00

805 1.00

PROJECT 0164013
LENGTH 3.492
LOW BID 715795.07
ENG EST 773762.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	3000.00	104	71677.00	130	249767.00
135	7265.00	136	13823.00	140	38069.00
141	418266.00	149	123930.00	157	123930.00
161	792.00	206	966.00	207	828.00
250	104020.00	447	450.00	448	1000.00
570	1500.00	572	500.00	574	600.00
712	11475.00	205	43459.00		

PROJECT 0164025
LENGTH 2.498
LOW BID 533601.52
ENG EST 567058.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	3512.00	104	42820.00	130	185052.00
135	5506.00	136	10593.00	140	9701.00
205	33095.00	206	736.00	207	631.00
250	82285.00	447	900.00	448	1907.00
712	3150.00	141	330700.00	149	97985.00
157	97985.00	161	616.00	204	19914.00
570	1000.00	572	250.00	574	400.00

PROJECT 0164045
LENGTH 3.624
LOW BID 667400.87
ENG EST 717788.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	3000.00	104	52081.00	130	231400.00
135	7448.00	136	14330.00	140	13116.00
205	44611.00	206	992.00	207	850.00
250	101968.00	712	9850.00	141	408666.00
149	121086.00	157	121086.00	161	761.00
204	24642.00	570	1000.00	572	250.00
574	400.00				

PROJECT 0264039
LENGTH 2.234
LOW BID 544858.00
ENG EST 525694.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2000.00	104	52551.00	130	177510.00
135	6961.00	136	9375.00	140	8647.00
141	246904.00	149	91446.00	157	91446.00
161	585.00	204	18289.00	205	29324.00
206	652.00	207	558.00	248	2524.00
250	74449.00	448	900.00	447	1003.00
570	1500.00	572	500.00	574	600.00

PROJECT 0364013
LENGTH 5.950

LOW BID 997471.98
ENG EST 1120784.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	3000.00	130	280972.00	135	13969.00
136	23516.00	140	21523.00	141	670656.00
149	198713.00	157	198713.00	161	1248.00
204	40440.00	205	73210.00	206	1627.00
207	1395.00	250	167337.00	570	3000.00
572	1000.00	574	1200.00	867	150.00
166	505.00				

PROJECT 0364019
LENGTH 0.000

LOW BID 403770.17
ENG EST 391178.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	1000.00	104	34813.00	119	5678.00
130	101882.00	141	141730.00	149	41994.00
157	41994.00	161	269.00	204	24869.00
205	13284.00	206	291.00	207	255.00
236	2460.00	238	1208.00	240	207.00
241	6298.00	250	36495.00	263	5483.00
430	9139.00	447	1125.00	448	1450.00
449	5954.00	466	213.00	501	133.00
502	20.00	712	3812.50	705	975.00
172	12705.00	173	564.00	570	700.00
572	300.00	574	280.00	575	500.00

PROJECT 0464019
LENGTH .891

LOW BID 473001.20
ENG EST 412958.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2000.00	130	119793.00	135	4035.00
136	5434.00	140	5174.00	205	17583.00
206	391.00	207	335.00	250	44467.00
249	17511.00	263	3153.00	278	6.00
430	1933.00	448	1583.00	447	3837.00
104	30485.00	141	241836.00	149	71655.00
157	71655.00	161	451.00	204	14507.00
570	1250.00	572	500.00	574	500.00

PROJECT 0664031
LENGTH 5.012

LOW BID 825856.88
ENG EST 871282.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2000.00	104	39512.00	130	325281.00
135	24924.00	136	28084.00	137	19871.00
138	28084.00	139	19871.00	140	65597.00
176	218.00	205	61863.00	206	1374.00
207	1178.00	250	141996.00	570	1800.00

572	600.00	574	720.00

PROJECT 0664019
LENGTH 4.272
LOW BID 799909.92
ENG EST 838516.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	4000.00	104	65081.00	130	269570.00
176	806.00	205	55793.00	206	1240.00
207	1063.00	250	132837.00	248	1441.00
447	2347.00	448	900.00	570	1000.00
572	500.00	574	400.00	135	22459.00
136	25379.00	137	17554.00	138	25379.00
139	17554.00	140	59403.00		

PROJECT 0664015
LENGTH 6.484
LOW BID 1125759.60
ENG EST 1183435.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2000.00	104	34496.00	130	379709.00
135	42894.00	136	38235.00	137	25953.00
138	38235.00	139	25953.00	140	88038.00
176	170.00	205	80950.00	206	1799.00
207	1542.00	250	193921.00	448	887.00
447	1009.00	570	2400.00	572	800.00
574	960.00	168	11894.00	166	128.00

PROJECT 0664027
LENGTH .891
LOW BID 377223.33
ENG EST 412958.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2000.00	130	119793.00	135	4035.00
136	5434.00	140	5174.00	205	17583.00
206	391.00	207	335.00	250	44467.00
249	17511.00	263	3153.00	278	6.00
430	1933.00	448	1583.00	447	3837.00
104	30485.00	141	241836.00	149	71655.00
157	71655.00	161	451.00	204	14507.00
570	1250.00	572	500.00	574	500.00

PROJECT 0964053
LENGTH 1.245
LOW BID 435242.01
ENG EST 397901.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	3287.00	104	29346.00	130	103915.00
135	4418.00	137	5141.00	729	5141.00
138	1471.00	140	3829.00	162	11074.00
163	645.00	164	3425.00	204	24747.00
205	15103.00	206	333.00	207	289.00
236	1042.00	238	559.00	240	91.00
250	53377.00	263	4323.00	430	4968.00

436	720.00	470	142.00	468	440.00
501	203.00	712	8862.00	136	1471.00
570	1200.00	572	300.00	574	480.00
575	200.00	838	84.00		

PROJECT 0964029
LENGTH 3.921
LOW BID 333587.87
ENG EST 373850.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
205	23345.00	206	519.00	207	444.00
236	476.00	102	1500.00	104	1600.00
130	75080.00	135	5161.00	163	698.00
164	3340.00	176	390.00	204	26715.00
240	31.00	250	54821.00	260	400.00
259	2238.00	137	8690.00	139	8690.00
140	9874.00	162	11992.00	430	225.00
448	217.00	712	1137.00	704	150.00
168	40360.00	166	436.00	767	102.00
766	83.00	570	1000.00	572	400.00
574	400.00	703	73.00		

PROJECT 0964025
LENGTH 7.019
LOW BID 619832.57
ENG EST 687387.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2000.00	119	12127.00	130	126621.00
135	8668.00	137	14594.00	139	14594.00
140	16644.00	162	21615.00	163	1258.00
164	6004.00	176	185.00	204	48031.00
205	40367.00	206	897.00	207	769.00
238	703.00	240	45.00	250	98276.00
260	560.00	259	4768.00	712	1787.00
704	100.00	168	93710.00	166	1012.00
767	156.00	766	244.00	570	1500.00
572	500.00	574	600.00	703	159.00

PROJECT 0964021
LENGTH 7.922
LOW BID 626081.34
ENG EST 689598.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2807.00	105	600.00	119	927.00
130	182317.00	135	8751.00	137	16850.00
139	16850.00	140	19301.00	162	23709.00
163	1376.00	164	6474.00	204	52912.00
205	49366.00	206	1098.00	207	941.00
238	542.00	240	35.00	250	111070.00
260	480.00	259	1761.00	275	3.00
302	179.00	318	40.00	655	39.00
668	440.00	703	123.00	848	295.00
168	31053.00	166	336.00	767	132.00
766	206.00	770	10.00	570	750.00

572	250.00	574	300.00

PROJECT 0964017
LENGTH 5.412
LOW BID 433424.28
ENG EST 479206.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	11575.00	130	134565.00	135	6071.00
137	11556.00	139	11556.00	140	13176.00
162	16181.00	163	942.00	164	4505.00
204	35809.00	205	32617.00	206	725.00
207	621.00	238	461.00	240	29.00
250	75854.00	260	360.00	259	1307.00
275	5.00	302	279.00	352	46.00
848	213.00	655	65.00	658	506.00
704	775.00	748	24.00	168	10516.00
166	114.00	767	96.00	766	206.00
570	2500.00	572	700.00	574	1000.00
738	1.00	703	255.00		

PROJECT 1164143
LENGTH 7.758
LOW BID 1058242.20
ENG EST 1177889.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	61229.00	105	83530.00	130	3052.00
848	1798.00	119	53765.00	130	110541.00
135	9617.00	137	18504.00	139	18504.00
140	21395.00	176	528.00	204	70216.00
205	72798.00	206	1609.00	207	1379.00
172	31618.00	173	1490.00	241	7677.00
250	130931.00	260	850.00	275	331.00
278	21.00	302	25438.00	316	228.00
317	114.00	318	116.00	343	160.00
838	1462.00	839	212.00	840	114.00
841	24.00	430	2792.00	470	2375.00
464	364.00	465	68.00	644	13867.00
238	290.00	240	19.00	262	9.00
724	31.00	749	60.00	166	1496.00
168	138541.00	729	616.00	740	1.38
735	33.00	709	3150.00	663	270.00
666	1.00	668	4.00	858	2.00
570	1500.00	572	500.00	574	600.00
712	5425.00	730	1600.00		

PROJECT 1264047
LENGTH 7.248
LOW BID 1361710.30
ENG EST 1493683.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2000.00	104	136873.00	119	2029.00
130	418735.00	135	15082.00	137	29002.00
139	29002.00	140	33630.00	204	103331.00
205	92348.00	206	2059.00	207	1763.00

238	524.00	240	34.00	241	13318.00
172	54236.00	173	2556.00	249	2174.00
250	213304.00	447	426.00	448	450.00
465	142.00	570	1500.00	572	500.00
574	600.00				

PROJECT 1264051
LENGTH 3.798

LOW BID 735470.88
ENG EST 796079.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	971.00	104	82642.00	105	200.00
130	218439.00	135	8000.00	137	15390.00
139	15390.00	140	17791.00	204	54038.00
205	48431.00	206	1078.00	207	923.00
172	27866.00	173	1313.00	241	6757.00
249	1281.00	250	114667.00	447	2884.00
448	425.00	465	85.00	644	299.00
663	364.00	665	742.00	570	1500.00
572	500.00	574	600.00	466	40.00

PROJECT 0465023
LENGTH 4.832

LOW BID 627698.32
ENG EST 594313.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	29258.00	103	20863.00	130	97107.00
135	5438.00	137	10424.00	139	10424.00
140	13320.00	162	17964.00	163	1043.00
164	6900.00	176	175.00	204	39269.00
205	39132.00	206	851.00	207	762.00
238	3607.00	240	230.00	249	76541.00
262	100.00	275	104.00	278	17.00
302	5232.00	319	88.00	344	40.00
430	7154.00	431	3373.00	447	158.00
461	1116.00	463	720.00	476	1.00
477	5.00	479	502.00	501	262.00
502	28.00	508	136.00	511	1.00
515	1.00	558	1460.00	559	1372.00
561	504.00	644	14055.00	650	189.00
654	1444.00	657	475.00	658	747.00
259	2297.00	666	25.00	667	40.00
663	7900.00	668	65.00	669	100.00
712	9100.00	838	222.00	839	72.00
840	52.00	665	4257.00	729	112.00
732	9716.00	740	.60	735	97.00
168	5667.00	166	61.00	767	96.00
570	450.00	572	150.00	574	180.00
868	603.00	577	63.00		

PROJECT 0665077
LENGTH 4.445

LOW BID 1187928.60
ENG EST 1245229.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	3812.00	103	5109.00	119	80830.00
130	382722.00	135	12702.00	136	994.00
137	18056.00	138	994.00	139	18056.00
140	22487.00	162	35164.00	163	2046.00
204	78318.00	176	600.00	205	59142.00
206	1518.00	207	1165.00	236	181.00
238	231.00	240	24.00	241	9965.00
248	9801.00	249	38313.00	250	121733.00
447	2488.00	448	2875.00	465	783.00
470	803.00	651	2957.00	712	22137.00
732	156284.00	740	9.80	735	2344.00
738	1.40	805	1.00	570	2700.00
572	700.00	574	1080.00	166	266.00
168	24640.00	104	300.00	263	3992.00
430	4182.00				

PROJECT 0665131
LENGTH 7.264

LOW BID 820689.39
ENG EST 702419.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	19216.00	104	16309.00	103	9819.00
105	825.00	130	199413.00	135	7323.00
137	14089.00	139	14089.00	140	18439.00
162	25916.00	163	1510.00	164	7509.00
176	133.00	204	56392.00	205	55468.00
206	1232.00	207	1056.00	249	108876.00
258	2501.00	259	4661.00	275	9.00
302	566.00	343	164.00	644	8125.00
653	57.00	658	568.00	662	490.00
712	7137.00	738	4.88	766	33.00
570	1500.00	572	500.00	574	600.00
805	1.00				

PROJECT 0965007
LENGTH 1.687

LOW BID 867831.28
ENG EST 832514.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	1000.00	130	171356.00	162	24197.00
163	1408.00	164	27594.00	165	67980.00
172	34894.00	173	1645.00	176	49.00
205	11610.00	207	370.00	236	8222.00
238	10970.00	250	51494.00	240	1102.00
249	5468.00	247	1660.00	263	13531.00
275	7.00	302	66.00	430	12410.00
432	2444.00	442	5018.00	461	366.00
463	15.00	468	953.00	501	294.00
502	62.00	570	900.00	572	300.00
574	360.00	647	253.00	662	106.00
658	565.00	673	19269.00	676	5.00
678	118.00	712	15316.00	713	6813.00
777	6813.00	778	2227.00	805	2.00

849	76.00	864	112.00	853	989.00
865	5.00	433	607.00		

PROJECT 0166005
LENGTH 6.531

LOW BID 1142063.50
ENG EST 1317457.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2000.00	104	71777.00	130	421771.00
135	17678.00	136	26455.00	139	26455.00
140	30762.00	141	896617.00	149	241513.00
157	241513.00	161	1455.00	166	659.00
168	54209.00	205	84001.00	206	1867.00
207	1600.00	250	193759.00	248	12603.00
448	1350.00	447	1716.00	465	266.00
470	373.00	570	1500.00	572	500.00
574	600.00	805	1.00		

PROJECT 0266017
LENGTH 2.860

LOW BID 637246.00
ENG EST 695638.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2000.00	104	40569.00	130	140048.00
135	8337.00	137	12476.00	139	12476.00
140	14639.00	141	43144.00	149	116302.00
157	116302.00	161	744.00	166	1002.00
168	82256.00	205	39892.00	206	887.00
207	760.00	250	88614.00	249	10725.00
318	276.00	448	900.00	447	1313.00
465	295.00	470	249.00	570	2700.00
572	900.00	574	1080.00	805	1.00
278	12.00	317	16.00		

PROJECT 0366031
LENGTH 2.005

LOW BID 592129.42
ENG EST 621632.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2000.00	104	17912.00	130	154310.00
162	31480.00	163	1831.00	164	14403.00
165	52103.00	238	2939.00	240	188.00
250	90134.00	263	5611.00	278	30.00
326	4.00	340	10.00	401	1.00
430	3511.00	445	163.00	444	564.00
465	479.00	470	464.00	502	2.00
570	500.00	572	500.00	574	200.00
744	576.00	805	2.00	849	4.00
853	56.00				

PROJECT 0566041
LENGTH 3.921

LOW BID 501918.44
ENG EST 473147.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	31451.00	104	3640.00	105	7800.00
115	1998.00	130	52368.00	135	6663.00
136	9974.00	139	9974.00	140	12840.00
172	13512.00	173	637.00	164	3315.00
165	26513.00	204	3930.00	166	938.00
168	77209.00	176	208.00	205	42273.00
206	940.00	207	806.00	244	55207.00
254	263.00	274	2.00	275	68.00
278	169.00	302	4684.00	319	44.00
522	2.00	570	1350.00	572	470.00
574	540.00	612	250.00	617	3.00
622	2.00	627	2.00	644	21593.00
704	1450.00	712	100.00	726	13.00
729	1928.00	805	1.00	839	128.00

PROJECT 0766097
LENGTH 5.419
LOW BID 516877.28
ENG EST 558518.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	24343.00	104	1823.00	105	14879.00
130	141209.00	135	8825.00	137	13206.00
139	13206.00	140	16894.00	162	17699.00
163	1031.00	164	5189.00	165	37746.00
166	253.00	168	20842.00	176	508.00
205	51300.00	206	1140.00	207	977.00
249	76340.00	274	1.00	275	55.00
278	37.00	302	3094.00	318	62.00
570	2000.00	572	667.00	574	800.00
644	24610.00	712	75.00	726	11.00
729	928.00	738	10.00	740	1.00
839	670.00	840	40.00	805	1.00

PROJECT 0766107
LENGTH 2.111
LOW BID 193226.07
ENG EST 207783.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	500.00	104	4935.00	130	59376.00
135	3633.00	136	5437.00	139	5437.00
140	6947.00	162	6228.00	163	362.00
164	1734.00	165	13875.00	166	105.00
168	8615.00	176	325.00	205	19606.00
206	436.00	207	373.00	249	29727.00
278	179.00	570	500.00	572	175.00
574	200.00	729	1266.00	805	1.00

PROJECT 1266129
LENGTH 1.279
LOW BID 429210.66
ENG EST 431482.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	12000.00	130	81957.00	135	2540.00

137	3917.00	139	3917.00	140	4355.00
204	27397.00	162	12298.00	163	716.00
164	6849.00	176	20.00	205	12115.00
206	267.00	207	232.00	250	61956.00
275	6.00	278	53.00	302	195.00
315	60.00	318	12217.00	430	14476.00
433	225.00	415	61.00	461	1361.00
477	3.00	479	30.00	502	8.00
570	750.00	574	300.00	572	250.00
575	100.00	645	1156.00	704	75.00
712	514.50	713	4160.50	729	14010.00
735	210.00	740	.90	777	4675.00
779	247.00	805	2.00		

PROJECT 1266111
LENGTH 1.999

LOW BID 477160.74
ENG EST 444042.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	5118.00	103	500.00	130	110231.00
135	12428.00	136	17789.00	137	8212.00
138	17798.00	139	6512.00	140	37718.00
166	326.00	168	26879.00	176	120.00
205	27894.00	206	620.00	207	536.00
249	65736.00	259	480.00	318	190.00
430	819.00	435	225.00	436	1090.00
470	306.00	570	1400.00	572	300.00
574	140.00	712	1050.00	766	23.00
768	31.00	769	2.00	805	2.00
201	21.00	202	8.00	644	720.00
663	830.00	665	410.00		

PROJECT 0264055
LENGTH 6.457

LOW BID 174271.70
ENG EST 191668.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
572	1025.00	103	550.00	113	19523.00
166	204.00	867	54.00	176	390.00
204	51686.00	205	77331.00	206	1431.00
207	1636.00	712	3050.00	278	100.00
738	13.00	766	41.00	767	92.00
732	45460.00	735	455.00	740	2.84
570	750.00	572	250.00	574	300.00
104	7054.00				

PROJECT 0364039
LENGTH 3.992

LOW BID 54311.77
ENG EST 59175.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
129	49.45	141	190075.00	153	214.00
161	400.00	204	5300.00	205	39200.00
206	871.00	207	747.00	176	25.00
872	2.00	873	4.00	145	49.45

PROJECT 0364113
LENGTH 2.488
LOW BID 39068.86
ENG EST 41395.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2393.00	119	1102.00	129	90.80
135	129112.00	145	78.79	146	13.65
153	119.46	161	249.00	155	13.65
204	7650.00	205	11137.00	206	530.00
770	12.00	457	69.50		

PROJECT 0464063
LENGTH 2.932
LOW BID 44475.49
ENG EST 47929.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
129	96.10	141	140868.00	145	96.10
153	158.00	161	293.00	176	45.00
204	3960.00	205	28389.00	206	631.00
207	541.00	828	104.00	770	14.00

PROJECT 0464093
LENGTH 5.094
LOW BID 189071.53
ENG EST 234042.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2500.00	119	21215.00	130	142000.00
141	614344.00	150	124110.00	158	124110.00
161	1058.00	176	362.00	179	25224.00
217	42679.00	219	1742.00	222	25.00
223	86.00	570	1200.00	572	100.00
574	480.00	766	74.00		

PROJECT 0464097
LENGTH 5.088
LOW BID 162969.24
ENG EST 202006.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	3380.00	119	2872.00	130	136302.00
141	611677.00	150	123561.00	158	123561.00
161	1053.00	176	300.00	179	25110.00
217	42502.00	219	1736.00	222	25.00
223	85.00	570	300.00	572	100.00
574	120.00	766	50.00		

PROJECT 0564121
LENGTH 1.796
LOW BID 33002.44
ENG EST 35272.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
141	90353.00	145	96.83	153	96.83
161	215.50	204	5380.00	205	19369.00
206	430.00	207	369.00	275	15.40

874	75.00	176	48.00

PROJECT 0764065
LENGTH 5.931
LOW BID 67849.82
ENG EST 77889.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
141	239477.00	145	17.50	153	313.30
161	480.00	204	7307.00	205	54803.00
206	1218.00	207	1044.00		

PROJECT 0864153
LENGTH 3.696
LOW BID 69857.79
ENG EST 71847.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	599.00	712	500.00	770	20.00
140	12651.00	205	35778.00	206	795.00
207	681.00	176	113.00	135	5680.00
136	10928.00	138	10928.00		

PROJECT 0864167
LENGTH 1.964
LOW BID 21158.97
ENG EST 23144.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
141	91994.00	145	103.94	161	166.00
176	85.00	179	5200.00	201	9100.00
202	371.00				

PROJECT 0864163
LENGTH 2.649
LOW BID 31153.34
ENG EST 34847.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
141	140000.00	145	31.75	153	139.75
161	219.00	176	50.00	179	8940.00
201	12823.00	202	523.00		

PROJECT 0864157
LENGTH 2.761
LOW BID 36883.52
ENG EST 39496.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
141	145800.00	145	95.80	153	145.80
161	229.00	176	85.00	179	9316.00
201	12471.00	202	509.00		

PROJECT 0864095
LENGTH 3.540
LOW BID 40126.77
ENG EST 42749.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
141	177000.00	153	186.95	161	390.00

179	8700.00	219	600.00	222	8.85
223	29.38	217	13000.00		

PROJECT 0864103 — LOW BID 232332.30
LENGTH 7.791 — ENG EST 280761.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2000.00	119	31266.00	141	579793.00
149	156173.00	157	156173.00	161	998.00
179	31084.00	176	282.00	217	52552.00
219	2131.00	222	32.00	223	106.00
254	894.00	430	155.00	465	22.00
470	25.00	570	1800.00	572	600.00
574	720.00	130	196970.00	712	575.00
767	84.00	766	15.00	278	434.00
729	2751.00	740	.17	735	55.00

PROJECT 0864141 — LOW BID 182826.17
LENGTH 5.702 — ENG EST 212961.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	4800.00	130	120439.00	141	559032.00
150	112927.00	158	112927.00	161	1041.00
179	23077.00	176	290.00	217	38708.00
219	1580.00	222	23.00	223	76.00
278	88.00	712	400.00	729	1703.00
732	103792.00	740	7.00	735	2076.00
739	19292.00	767	42.00	766	82.00
570	750.00	572	250.00	574	300.00

PROJECT 0864145 — LOW BID 142241.85
LENGTH 3.837 — ENG EST 170712.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	1250.00	119	15915.00	130	87289.00
141	377466.00	150	76250.00	158	76250.00
161	719.00	179	15589.00	176	250.00
217	26136.00	219	1067.00	222	16.00
223	51.00	278	96.00	712	200.00
729	1876.00	732	52536.00	733	56704.00
740	7.00	735	2185.00	739	9418.00
767	31.00	766	14.00	570	750.00
572	250.00	574	300.00	353	24.00
275	2.00	302	42.00		

PROJECT 0964037 — LOW BID 225851.27
LENGTH 5.482 — ENG EST 274717.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2000.00	119	33000.00	130	157157.00

141	655865.00	150	132461.00	158	132461.00
161	1096.00	176	220.00	204	26958.00
217	45544.00	219	1849.00	222	27.00
223	91.00	570	1500.00	572	500.00
574	600.00	766	34.00	767	65.00
712	3450.00				

PROJECT 0964041
LENGTH 4.921
LOW BID 203639.25
ENG EST 247087.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2000.00	119	31567.00	130	150133.00
141	585702.00	150	118324.00	158	118324.00
161	991.00	176	225.00	204	24076.00
217	40694.00	219	1652.00	222	25.00
223	82.00	570	1500.00	572	500.00
574	600.00	766	62.00	767	15.00
712	1900.00				

PROJECT 0365091
LENGTH 1.232
LOW BID 48792.00
ENG EST 51412.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	4208.00	130	35303.00	141	155212.00
150	31356.00	158	31356.00	161	256.00
204	6375.00	176	83.00	217	10793.00
219	441.00	222	6.00	223	21.00
712	425.00	570	375.00	572	125.00
574	150.00				

PROJECT 0465029
LENGTH 6.746
LOW BID 82634.09
ENG EST 96172.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
129	359.19	141	338231.00	157	359.19
161	518.00	179	16814.00	217	28041.00
219	1145.00	222	17.00	223	56.00
712	2357.00	875	168.75	876	330.00
770	31.00	767	134.00		

PROJECT 0665107
LENGTH 1.518
LOW BID 73099.49
ENG EST 83165.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	500.00	176	90.00	712	125.00
119	8313.00	130	36362.00	141	208007.00
150	42022.00	158	42022.00	161	358.00
217	14494.00	219	592.00	179	8539.00
168	10733.00	166	130.00	767	37.00
570	300.00	572	100.00	574	120.00

222	9.00	223	30.00	805	1.00

PROJECT 0765139 LOW BID 74551.22
LENGTH 5.372 ENG EST 78222.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
141	247775.00	153	294.00	161	477.00
176	130.00	204	14355.00	205	53890.00
206	1196.00	207	1026.00	875	149.22
876	197.00	767	96.00		

PROJECT 0765123 LOW BID 22876.68
LENGTH 2.003 ENG EST 24445.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
141	101084.00	153	105.81	161	169.00
176	60.00	179	5480.00	217	9179.00
219	375.00	222	5.50	223	18.30

PROJECT 0965017 LOW BID 20966.08
LENGTH 3.000 ENG EST 19417.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
141	71280.00	157	158.00	161	135.00
204	6336.00	217	12675.00	219	604.00
222	9.00	223	30.00	805	1.00

PROJECT 0166077 LOW BID 207653.94
LENGTH 6.452 ENG EST 244782.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	13988.00	104	3198.00	117	2118.00
129	337.60	141	661633.00	149	133664.00
157	133664.00	161	1118.00	176	530.00
179	27196.00	201	45935.00	202	1872.00
275	5.00	302	112.00	442	3526.00
457	383.00	161	23.00	464	188.00
479	58.00	501	30.00	502	4.00
511	2.00	558	64.00	559	120.00
570	750.00	572	250.00	574	300.00
644	5446.00	663	1287.00	654	29.00
666	15.00	667	27.00	668	9.00
669	2.00	712	3825.00	839	86.00
767	87.00	732	2113.00	805	1.00
105	50000.00				

PROJECT 0466147 LOW BID 216646.68
LENGTH 7.023 ENG EST 257541.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
117	22077.00	130	162105.00	141	709670.00
149	143366.00	157	143366.00	161	1223.00
204	29318.00	176	300.00	201	49234.00
202	2007.00	457	115.00	570	1500.00
572	500.00	574	600.00	712	500.00
767	27.00	805	1.00		

PROJECT 0566085
LENGTH 4.077
LOW BID 118906.06
ENG EST 149002.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
117	14281.00	130	92677.00	141	391917.00
150	79172.00	157	79172.00	161	675.00
204	16080.00	176	470.00	201	27106.00
202	1107.00	570	1000.00	572	600.00
574	400.00	712	425.00	805	1.00

PROJECT 0566081
LENGTH 3.983
LOW BID 110446.41
ENG EST 140140.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
117	12122.00	130	88707.00	141	382261.00
150	77221.00	157	77221.00	161	658.00
204	15780.00	176	163.00	201	26445.00
202	1080.00	570	1000.00	572	600.00
574	400.00	805	1.00		

PROJECT 0566051
LENGTH 2.500
LOW BID 47256.16
ENG EST 47807.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
106	2.50	141	124410.00	150	9058.00
157	33000.00	161	207.00	204	6749.00
201	11289.00	202	460.00	353	450.00

PROJECT 0566047
LENGTH 2.800
LOW BID 51750.36
ENG EST 52911.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
106	2.80	141	139339.00	150	10145.00
157	36960.00	161	231.00	204	7556.00
201	12649.00	202	516.00	353	250.00

PROJECT 0566021
LENGTH 3.000
LOW BID 46285.24
ENG EST 47911.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
106	3.00	141	115760.00	150	8369.00

156	26190.00	157	13200.00	161	193.00
204	8020.00	201	13549.00	202	553.00
353	500.00				

PROJECT 0566007
LENGTH 1.300
LOW BID 18028.74
ENG EST 18335.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
106	1.30	141	42897.00	150	3085.00
157	17022.00	161	71.00	204	3460.00
201	5872.00	202	240.00	353	150.00

PROJECT 0566011
LENGTH 1.900
LOW BID 34957.84
ENG EST 35419.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
106	1.90	141	94552.00	150	6884.00
157	25080.00	161	157.00	204	5128.00
201	8583.00	202	351.00	353	200.00

PROJECT 0566003
LENGTH 3.200
LOW BID 34814.58
ENG EST 38064.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
106	3.20	141	120323.00	157	42071.00
161	220.00	204	8572.00	201	14449.00
202	590.00	353	200.00		

PROJECT 0666089
LENGTH 4.001
LOW BID 55077.50
ENG EST 63276.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2000.00	141	231144.00	150	76096.00
161	486.00	204	15219.00	176	95.00
201	26633.00	202	1088.00	433	50.00
570	300.00	572	100.00	574	120.00
805	1.00				

PROJECT 0866139
LENGTH 3.829
LOW BID 104633.07
ENG EST 136380.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
117	9246.00	130	85137.00	141	377713.00
150	76305.00	157	76305.00	161	651.00
209	15697.00	176	158.00	201	26160.00
202	1068.00	570	1500.00	574	600.00
572	500.00	767	96.00	805	1.00

PROJECT 0866095 LOW BID 27243.11
LENGTH 2.004 ENG EST 29384.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
141	101550.00	150	107.00	157	107.00
161	168.00	176	80.00	209	5496.00
201	9207.00	202	376.00	712	200.00

PROJECT 0866091 LOW BID 37887.75
LENGTH 2.869 ENG EST 41870.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
141	145390.00	150	153.54	157	153.54
161	244.00	176	55.00	204	7882.00
201	13275.00	202	539.00		

PROJECT 0767151 LOW BID 266795.37
LENGTH 5.050 ENG EST 269155.69

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	750.00	103	750.00	104	2698.00
130	73105.00	166	594.00	168	48889.00
172	31789.00	173	1498.00	164	9576.00
165	39191.00	176	115.00	205	22482.00
206	500.00	207	428.00	238	4991.00
240	319.00	570	1500.00	572	500.00
574	600.00	805	1.00	712	3000.00

PROJECT 0767067 LOW BID 431438.56
LENGTH 4.324 ENG EST 463282.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	1500.00	103	1500.00	104	9710.00
110	75.00	130	111852.00	172	41894.00
173	1974.00	164	15734.00	176	108.00
102	42031.00	205	30547.00	206	679.00
207	582.00	236	9569.00	238	4662.00
240	802.00	570	750.00	572	250.00
574	300.00	712	27500.00	770	24.00
805	1.00				

PROJECT 0167077 LOW BID 346307.19
LENGTH 6.865 ENG EST 330780.56

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	1000.00	104	846.00	103	1000.00
129	63614.00	162	35616.00	163	2073.00
164	13122.00	165	53760.00	166	1127.00
168	92889.00	176	528.00	205	30817.00

206	613.00	207	591.00	236	9078.00
240	579.00	457	65.00	570	900.00
572	300.00	574	360.00	767	28.00
805	2.00	712	4529.00	770	16.00

PROJECT 0367083
LENGTH 7.615
LOW BID 543694.12
ENG EST 664098.31

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	3250.00	106	1000.00	104	1784.00
129	283822.00	162	83646.00	163	4868.00
164	42295.00	165	86081.00	166	240.00
168	19728.00	176	180.00	205	69759.00
206	1550.00	207	1329.00	236	19060.00
238	8794.00	240	1512.00	275	28.00
276	3.00	302	2809.00	353	158.00
435	643.00	436	657.00	470	162.00
570	1500.00	572	500.00	574	600.00
712	3900.00	766	67.00	770	20.00
805	1.00				

PROJECT 0467051
LENGTH 6.812
LOW BID 618863.00
ENG EST 637349.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
103	1000.00	117	38148.00	162	70890.00
163	4126.00	164	35644.00	165	74383.00
166	182.00	168	14934.00	176	385.00
205	54443.00	206	1210.00	207	1038.00
236	16516.00	238	8053.00	240	1384.00
432	1350.00	470	391.00	570	450.00
572	150.00	574	180.00	651	723.00
712	10738.00	768	2.00	769	6.00
770	17.00	805	2.00	110	8.00
129	201519.00				

PROJECT 0667159
LENGTH 5.997
LOW BID 433476.00
ENG EST 530790.62

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	12662.00	103	500.00	104	1445.00
105	1600.00	111	2182.00	130	188189.00
162	67666.00	163	3938.00	164	34777.00
165	69538.00	176	820.00	205	61793.00
206	1373.00	207	1177.00	236	14000.00
238	7389.00	240	1209.00	275	16.00
276	9.00	278	122.00	302	1650.00
317	64.00	344	88.00	447	456.00
465	35.00	570	3000.00	572	1000.00
574	1200.00	715	5050.00	716	8.00
729	532.00	732	642.00	738	3.20

740	0.50	805	1.00	839	78.00
840	72.00	841	34.00		

PROJECT 0667035 LOW BID 627365.94
LENGTH 4.609 ENG EST 757404.19

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	3000.00	103	12013.00	104	3149.00
130	116473.00	162	91026.00	163	5271.00
164	45993.00	165	86727.00	166	1991.00
168	163800.00	205	57390.00	206	1264.00
207	1102.00	236	20394.00	238	9935.00
240	1708.00	805	0.0	570	2000.00
572	500.00	574	800.00		

PROJECT 0667041 LOW BID 579312.00
LENGTH 3.675 ENG EST 712948.69

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	1000.00	103	9856.00	104	5051.00
130	266615.00	162	97499.00	163	5673.00
164	45140.00	165	82153.00	176	22.00
205	51004.00	206	1071.00	207	1013.00
236	18812.00	238	9173.00	240	1576.00
435	351.00	436	900.00	465	193.00
570	1500.00	572	500.00	574	2158.00
805	2.00				

PROJECT 0667137 LOW BID 647828.19
LENGTH 6.758 ENG EST 808943.87

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	92295.00	103	2679.00	105	39126.00
130	82434.00	162	85019.00	163	4949.00
164	42467.00	165	86817.00	166	1558.00
168	128268.00	176	603.00	205	62073.00
206	1338.00	207	1224.00	236	18378.00
238	9415.00	240	1569.00	275	76.00
276	6.00	278	146.00	302	3972.00
570	750.00	572	250.00	574	300.00
644	4980.00	646	1360.00	712	13850.00
726	41.00	729	1025.00	732	46012.00
735	706.00	740	2.90	767	36.00
768	14.00	770	30.00	805	1.00
819	194.00				

PROJECT 0667151 LOW BID 571124.25
LENGTH 4.279 ENG EST 729604.56

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE

102	6195.00	103	1000.00	111	826.00
130	243204.00	162	96119.00	163	5596.00
164	47881.00	165	100169.00	176	515.00
205	72034.00	206	1602.00	207	1374.00
236	22216.00	238	10903.00	240	1867.00
276	15.00	302	934.00	317	250.00
435	470.00	436	96.00	441	150.00
442	450.00	465	62.00	570	1500.00
572	500.00	574	600.00	738	1.29
740	0.20	805	1.00	819	28.00

PROJECT 0667155
LENGTH 5.253
LOW BID 354666.87
ENG EST 448119.87

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	1000.00	103	1000.00	130	172989.00
162	59917.00	163	3483.00	164	30404.00
165	62147.00	176	443.00	205	51856.00
206	1153.00	207	988.00	236	12713.00
238	6195.00	240	1065.00	432	246.00
465	25.00	470	135.00	570	1500.00
572	500.00	574	600.00	805	1.00

PROJECT 0767185
LENGTH 6.119
LOW BID 450737.75
ENG EST 571688.06

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	35042.00	103	5433.00	105	71000.00
110	301.00	111	3723.00	130	49650.00
162	61596.00	163	3584.00	164	30494.00
165	62410.00	166	1577.00	168	129792.00
176	1080.00	205	48392.00	206	1068.00
207	916.00	236	13537.00	238	6594.00
240	1134.00	274	5.00	275	83.00
276	21.00	278	30.00	302	9432.00
343	126.00	344	56.00	524	200.00
570	750.00	572	250.00	574	300.00
712	1800.00	726	20.00	738	5.60
740	0.84	770	12.00	805	2.00
839	502.00				

PROJECT 0767147
LENGTH 5.537
LOW BID 393753.50
ENG EST 426065.06

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	4935.00	103	2123.00	105	2123.00
130	84808.00	162	55689.00	163	3242.00
164	25301.00	165	56122.00	166	890.00
168	73216.00	176	175.00	205	42099.00
206	936.00	207	802.00	238	6188.00
240	396.00	275	9.00	278	11.00

302	450.00	570	1050.00	572	350.00
574	420.00	712	6425.00	726	4.00
729	42.00	738	0.60	740	0.10
770	36.00	805	1.00	839	198.00
111	389.00	104	1197.00		

PROJECT 0767155
LENGTH 4.254
LOW BID 262968.62
ENG EST 272304.44

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2500.00	103	1000.00	117	10564.00
130	17185.00	162	29659.00	163	1718.00
164	12345.00	165	33780.00	166	1002.00
168	82326.00	176	495.00	205	19202.00
206	425.00	207	366.00	238	4229.00
240	271.00	457	65.00	570	1500.00
572	500.00	574	600.00		

PROJECT 0767159
LENGTH 2.054
LOW BID 119514.00
ENG EST 129862.00

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	644.00	103	500.00	104	2716.00
130	47943.00	162	18293.00	163	1065.00
164	7874.00	165	20345.00	166	106.00
168	8689.00	176	85.00	205	15151.00
206	337.00	207	289.00	238	2958.00
240	189.00	570	375.00	572	125.00
574	150.00	712	1025.00	770	8.00
805	1.00				

PROJECT 0767165
LENGTH 4.509
LOW BID 306051.75
ENG EST 335301.19

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	2500.00	103	2500.00	130	78795.00
162	41369.00	163	2408.00	164	17416.00
165	46471.00	166	604.00	168	49700.00
176	485.00	205	34519.00	206	768.00
207	658.00	238	6531.00	240	417.00
570	3000.00	572	1000.00	574	1200.00
712	8150.00	767	22.00	770	15.00
805	1.00	441	153.00	442	194.00

PROJECT 0967049
LENGTH 2.326
LOW BID 219288.94
ENG EST 222024.87

ITEM	MAGNITUDE	ITEM	MAGNITUDE	ITEM	MAGNITUDE
102	13402.00	103	500.00	105	452.00
130	69339.00	162	23951.00	163	1394.00

164	11851.00	176	213.00	204	25033.00
205	19160.00	206	426.00	207	365.00
236	5699.00	238	2779.00	240	477.00
276	7.00	278	23.00	302	328.00
316	16.00	436	1593.00	470	67.00
570	300.00	572	100.00	574	120.00
712	3575.00	729	500.00	732	20679.00
735	212.00	740	1.30	759	82.00
805	1.00	848	669.00		

APPENDIX B

PAGES EXTRACTED FROM A "NOTICE TO CONTRACTORS

OKLAHOMA DEPARTMENT OF HIGHWAYS

LETTING OF NOVEMBER 26, 1968

(Amounts Do Not Include Engineering and Contingencies)

Issued by Office Engineer

PROJECT NO.	WORKING DAYS	COUNTY	HWY.	DESCRIPTION-LOCATION	AMOUNT
SAP-7(23)	45	Bryan	US 70	0.000 mile Repair Rip Rap, Beg. at the Bryan-Marshall C/L & Ext. E. - N. Side of US 70.	$ 57,500.00
SAP-8(18)	30	Caddo	Fort Cobb Lake Rd.	1.000 mi. Bitum. Surf., Single Treatment on Soil Asph. Base, Beg. at N.W. Cor.Sec. 19 T-9N, R12W & Ext. South.	$ 18,747.90
SAP-20(21)	40	Custer	Foss Lake Access Rd.	1.800 Mi. Bitum. Surf. Single Treatment on Soil Asph. Base, Beg. at SH 73 & Ext. E. & N. to Foss Lake.	$ 33,745.18
SAP-20(23)	40	Custer	Foss Lake Access Rd.	1.800 Mi Bitum. Surf. Single Treatment on Soil Asph. Base, Beg. at SH 44 & Ext. West to Foss Lake.	$ 33,745.18
S-39(15)S	180	Murray	SH 7	1.061 Mis. Gr., Dr. & P.C.Conc. Surf. on Fine Aggr. Bit.Base with Fine Aggr. Bit.Base Widening & Asph. Conc. Surf. & Resurf.Beg. at US 177 & Ext. E. in Sulphur.	$ 291,971.97
SAP-48(19)	40	Marshall	Texhoma Lake Rd.	1.500 Mis. Bit. Surf. Sing.Treatment on Soil Asph. Base, Beg. S. of Shay & Ext. S. to Church Camp.	$ 28,126.94
SAP-48(25)	30	Marshall	Texhoma Lake Rd.	1.000 Mi. Bitum. Surf. Single Treatment on Soil Asph. Base, Beg. S. of Shay & Ext. S. to Arrowhead Point.	$ 18,747.90

NOTICE TO CONTRACTORS: Sealed proposals by REGISTERED MAIL will be received through the Capitol Substation Post Office until 1:30 P.M. and will be received at the State Highway Commission Room in the Jim Thorpe Building from 1:30 P.M. to 2:00 P.M. **November 26, 1968** to be publicly opened and read at 2:00 P.M. for the work listed below.

Each separate proposal shall be accompanied by a Certified Check or Cashier's Check in the amount as stated in the proposal and made payable to the State of Oklahoma, Department of Highways, as a proposal guaranty.

This work will be done under the Oklahoma State Highway Commission's Applicable Specifications for Highway Construction.

The minimum wage to be paid **laborers** employed on this project will be included in the proposal.

When Federal funds are involved the proposal will include a Special Provision with reference to Contractor's Affidavit required by Section 112 of Title 23 USC as amended.

Examination of Plans, Specifications, Special Provisions and Site of Work is required.

Proposals must be prepared as directed by the State Standard Specifications.

Plans, forms of proposals, contracts and specifications may be examined at the Division Engineer's Office at **Ada**, Oklahoma, or at the Chief Engineer's Office, Oklahoma City. Plans may be secured through the Chief Engineer's Office at 25 cents per sheet. Proposal forms must be secured from the Prequalification Office, Department of Highways, 317 N.E. 21st Street, State Highway Annex No. 3, Oklahoma City, Oklahoma.

Description of work and location of project:

Federal Aid Secondary Project No. S-39(15)S, consisting of 1.061 Miles of Grading, Drainage and Portland Cement Concrete Surfacing on Fine Aggregate Bituminous Base with Fine Aggregate Bituminous Base Widening and Asphaltic Concrete Surfacing and Resurfacing on SH 7, beginning at US 177 and extending East in Sulphur, Murray County, Oklahoma - AMOUNT OF PROPOSAL BID CHECK: $10,000.00 - STATE OF OKLAHOMA, DEPARTMENT OF HIGHWAYS - By: Earl Anderson, Chief Engineer

Federal Aid Secondary Project No. S-39(15)S, consisting of 1.061 Miles of Grading, Drainage and Portland Cement Concrete Surfacing on Fine Aggregate Bituminous Base with Fine Aggregate Bituminous Base Widening and Asphaltic Concrete Surfacing and Resurfacing on SH 7, beginning at US 177 and extending East in Sulphur, Murray County, Oklahoma.

APPROXIMATE QUANTITIES

Uncl. Exc.	C.Y.	18,481.	Removing Trees 19" to 24"		
Overhaul	SEC.YD.	1,389.	in dia.	EA.	11.
Aggr.	TON	6,985.	Removing Trees 25" & more		
Asph.	TON	407.	in dia.	EA.	2.
Traf. Bound Surf. Cse., Type A	C.Y.	183.	Beam Type Guard Rail (Sgl.)	L.F.	325.
Tack Coat	GAL.	2,174.	Right-of-Way Fence,Type II		
Prime Coat	GAL.	9,053.	(6' High)	L.F.	292.
Type C Aggr.	TON	444.	Gates, Type II (6'x8')	EA.	1.
Asph.	TON	29.	Right-of-Way Markers	EA.	6.
8" P.C. Conc. Pav't.	S.Y.	27,611.	Mulch Sodding	S.Y.	8,396.
9" H.E.S. Conc. Pav't.(Patching)	S.Y.	60.	Watering	M.GAL.	126.
8" H.E.S. Conc. Pav't.	S.Y.	4,567.	Fertilizing(13-13-13)	TON	0.6
Class A Conc.	C.Y.	13.	2" Galv. Steel Elect.		
Class A Conc. (Small Str.)	C.Y.	34.	Conduit	L.F.	56.
Class C Conc.	C.Y.	66.	3" Galv. Steel Elect.		
Reinforcing Steel	LB.	1,916.	Conduit	L.F.	56.
6" Integral Curb	L.F.	8,041.	Pull Boxes - Type 1	EA.	2.
4" Conc. Sidewalk	S.Y.	262.	Field Office and Laboratory	EA.	1.
6" Conc. Driveway (H.E.S. Conc.)	S.Y.	693.	Grates "A" (GPI)	EA.	1.
Manhole (4' Dia.)	EA.	2.	Grates "B" (GPI)	EA.	1.
Manhole Frame & Cover (Type A)	EA.	2.			
Manhole Frame & Cover (Type B)	EA.	2.			
Inlet Brick Mas.	C.F.	1,708.			
Sp. Inlet Curb	L.F.	517.			
Inlet Frame & Grate (SGF-1)	EA.	48.			
Brick Mas. in Jct. Boxes	C.F.	94.			
18" R.C. Pipe	L.F.	306.			
24" R.C. Pipe	L.F.	1,118.			
30" R.C. Pipe	L.F.	120.			
42" R.C. Pipe	L.F.	8.			
48" R.C. Pipe	L.F.	80.			
6" Cast Iron Pipe	L.F.	12.			
Perf. Pipe Underdrain	L.F.	750.			
Non-Perf. Pipe Underdrain	L.F.	250.			
Pipe Underdrain Cover Mat'l.	C.Y.	300.			
Removal of 2'-0" Comb. Curb & Gutter	L.F.	312.			
Removal of Conc. Driveway	S.Y.	524.			
Removal of Conc. Sidewalk	S.Y.	192.			
Removal of Asph. Pav't.	S.Y.	19,272.			
Removing Trees 6" to 12" in dia.	EA.	28.			
Removing Trees 13" to 18" in dia.	EA.	20.			

STATE OF OKLAHOMA
DEPARTMENT OF HIGHWAYS

By: Earl Anderson
Chief Engineer

APPENDIX C

INDIVIDUAL PROJECT ESTIMATES FROM THE REGRESSION ANALYSES

REGRESSION I

P C CONCRETE PAVEMENT PROJECTS

PROJECT	LOW BID	ENG EST	REG EST	PRCNT DEVIATION EE	RE
0164013	715795.07	773726.01	735017.85	-8.09	-2.68
0164025	533601.52	567057.83	527092.57	-6.26	1.21
0164045	667400.87	717788.01	667541.32	-7.54	-.02
0264039	544858.00	525694.46	501647.07	3.51	7.93
0364013	997471.98	1120784.00	983798.16	-12.36	1.37
0364019	403770.17	391177.77	426700.43	3.11	-5.67
0464019	473001.20	412958.22	422299.51	12.69	10.71
0664031	825856.88	871282.09	827248.96	-5.50	-.16
0664019	799909.92	838516.10	788849.35	-4.82	1.38
0664015	1125759.60	1183435.60	1116954.80	-5.12	.78
0664027	377223.33	412958.22	422299.51	-9.47	-11.94
0964053	435242.01	397901.05	424818.29	8.57	2.39
0964029	333587.87	373850.85	328725.66	-12.06	1.45
0964025	619832.57	687387.59	639952.37	-10.89	-3.24
0964021	626081.34	689598.69	605584.67	-10.14	3.27
0964017	433424.28	479205.76	423764.64	-10.56	2.22
1164143	1058242.20	1177889.90	1054716.70	-11.30	.33
1264047	1361710.30	1493683.30	1375764.80	-9.69	-1.03
1264051	735470.88	796078.83	740647.28	-8.24	-.70
0465023	627698.32	594313.42	633513.84	5.31	-.92
0665077	1187928.60	1245228.50	1184660.40	-4.82	.27
0665131	820689.39	702419.88	779003.85	14.41	5.07
0965007	867831.28	832514.12	861179.33	4.06	.76
0166005	1142063.50	1317457.70	1161952.40	-15.35	-1.74
0266017	637246.00	695638.18	657401.36	-9.16	-3.16
0366031	592129.42	621632.55	609764.22	-4.98	-2.97
0566041	501918.44	473147.15	458729.36	5.73	8.60
0766097	516877.28	558518.02	538338.57	-8.05	-4.15
0766107	193226.07	207783.83	200212.91	-7.53	-3.61
1266129	429210.66	431482.27	422863.59	-.52	1.47
1266111	477160.74	444042.83	495720.48	6.94	-3.88

REGRESSION I

ASPHALTIC CONCRETE PAVEMENT PROJECTS

PROJECT	LOW BID	ENG EST	REG EST	PRCNT DEVIATION EE	RE
0264035	1207121.90	1313944.20	1255684.30	-8.84	-4.02
0264023	352495.91	368792.94	358707.48	-4.62	-1.76
0264029	1111918.50	1242730.70	1111596.50	-11.76	.02
0264017	500591.44	533163.15	520474.33	-6.50	-3.97
0364005	181914.33	184056.22	185536.52	-1.17	-2.00
0464015	1048058.90	1197934.00	1058717.50	-14.30	-1.01
0464023	1466789.30	1583026.00	1444797.30	-7.92	1.49
0464071	105410.34	122630.94	108765.22	-16.33	-3.18
0564053	233918.85	297389.88	233691.62	-27.13	.09
0564033	957869.33	1110232.10	966256.85	-15.90	-.87
0564037	1017401.40	1218567.60	1044620.30	-19.77	-2.67
0764011	1134814.60	1155743.80	1067776.20	-1.84	5.90
0864005	230034.79	277153.76	243700.20	-20.48	-5.94
0864137	285403.05	302905.85	319566.14	-6.13	-11.97
0864129	285806.93	290502.14	290566.22	-1.64	-1.66
0864077	641346.21	670160.73	654702.46	-4.49	-2.08
0864089	248715.53	277940.64	266030.99	-11.75	-6.96
0864083	248866.79	278597.76	254849.75	-11.94	-2.40
0964071	395771.43	423084.43	386943.02	-6.90	2.23
0964013	476782.47	503934.95	465990.22	-5.69	2.26
0964009	1304253.90	1404357.90	1286423.30	-7.67	1.36
0964005	210926.13	265778.19	241289.55	-26.00	-14.39
1264067	366978.72	457712.51	385366.88	-24.72	-5.01
0165029	439081.01	462225.49	425940.97	-5.27	2.99
0365103	169166.60	167603.81	169571.74	.92	-.23
0465079	610761.50	630547.99	607627.09	-3.20	.51
0765127	430303.99	452351.66	440182.03	-5.12	-2.29
0665087	255423.57	266143.38	231219.20	-5.01	8.76
0765083	51786.22	55071.41	49650.55	-6.34	4.12
1065059	333967.77	350378.21	332755.51	-4.91	.36
0166043	738348.08	808884.53	757235.84	-9.55	-2.55
0266023	352281.11	391790.93	347631.26	-11.21	1.31
0366121	434447.46	472215.27	457998.77	-8.69	-5.42
0366027	1357665.30	1397669.40	1348108.20	-2.94	.70
0466033	494391.09	540022.06	478484.43	-9.22	3.21
0466041	376124.63	414738.86	390840.41	-10.26	-3.91
0466037	493983.26	569514.03	499008.85	-15.29	-1.01
0666115	163720.75	123258.37	131261.03	24.71	19.82
0666131	147280.88	138461.36	135838.09	5.98	7.76
0666007	458302.60	440527.89	434055.82	3.87	5.29
0766101	185926.17	208130.99	186265.53	-11.94	-.18
0766091	742766.84	828864.15	739318.49	-11.59	.46
0766063	646332.67	676007.15	644482.33	-4.59	.28
0866121	97749.49	91545.19	94005.99	6.34	3.82
0866117	153262.35	143332.45	152296.17	6.47	.63
1066019	239817.23	245345.09	231938.61	-2.30	3.28

REGRESSION I

SECONDARY BITUMINOUS PAVEMENT PROJECTS

PROJECT	LOW BID	ENG EST	REG EST	PRCNT DEVIATION EE	RE
0264055	174271.70	191668.25	179342.66	-9.98	-2.90
0364039	54311.77	59175.65	53370.60	-8.95	1.73
0364113	39068.86	41394.67	47336.03	-5.95	-21.16
0464063	44475.49	47929.05	43719.04	-7.76	1.70
0464093	189071.53	234042.02	196508.95	-23.78	-3.93
0464097	162969.24	202005.82	165743.16	-23.95	-1.70
0564121	33002.44	35272.19	33392.77	-6.87	-1.18
0764065	67849.82	77889.58	71048.99	-14.79	-4.71
0864153	69857.79	71846.85	94245.60	-2.84	-34.91
0864167	21158.97	23144.46	19007.68	-9.38	10.16
0864163	31153.34	34846.93	29850.25	-11.85	4.18
0864157	36883.52	39495.76	32878.36	-7.08	10.85
0864095	40126.77	42749.77	38016.79	-6.53	5.25
0864103	232332.30	280761.28	239500.10	-20.84	-3.08
0864141	182826.17	212961.13	174951.02	-16.48	4.30
0864145	142241.85	170711.75	144941.98	-20.01	-1.89
0964037	225851.27	274717.88	233546.16	-21.63	-3.40
0964041	203639.25	247087.32	215650.61	-21.33	-5.89
0365091	48792.00	51412.37	44879.13	-5.37	8.01
0465029	82634.09	96172.70	65419.08	-16.38	20.83
0665107	73099.49	83105.26	69460.96	-13.68	4.97
0765139	74551.22	78222.40	51887.61	-4.92	30.40
0765123	22876.68	24445.46	20884.95	-6.85	8.70
0965017	20966.08	19417.33	19981.38	7.38	4.69
0166077	207653.94	244782.73	187373.29	-17.88	9.76
0466147	216646.68	257541.94	214204.73	-18.87	1.12
0566085	118906.06	149002.54	116288.55	-25.31	2.20
0566081	110446.41	140140.64	120671.62	-26.88	-9.25
0566051	47256.16	47807.39	46507.45	-1.16	1.58
0566047	51750.36	52911.30	50950.13	-2.24	1.54
0566021	46285.24	47911.74	47141.20	-3.51	-1.84
0566007	18028.74	18335.24	20569.49	-1.70	-14.09
0566011	34957.84	35419.76	35337.71	-1.32	-1.08
0566003	34814.58	38064.22	36545.90	-9.33	-4.97
0666089	55077.50	63276.15	52193.20	-14.88	5.23
0866139	104633.07	136380.57	103753.95	-30.34	.84
0866095	27243.11	29384.49	25179.80	-7.86	7.57
0866091	37887.75	41870.93	36669.43	-10.51	3.21

REGRESSION II

P C CONCRETE PAVEMENT PROJECTS

PROJECT	LOW BID	ENG EST	REG EST	PRCNT DEVIATION EE	RE
0164013	715795.07	773726.01	718849.55	-8.09	-.42
0164025	533601.52	567057.83	528558.83	-6.26	.94
0164045	667400.87	717788.01	663185.17	-7.54	.63
0264039	544858.00	525694.46	494239.92	3.51	9.29
0364013	997471.98	1120784.00	1009380.30	-12.36	-1.19
0364019	403770.17	391177.77	433615.14	3.11	-7.39
0464019	473001.20	412958.22	431589.31	12.69	8.75
0664031	825856.88	871282.09	830534.18	-5.50	-.56
0664019	799909.92	838516.10	766927.97	-4.82	4.12
0664015	1125759.60	1183435.60	1123230.70	-5.12	.22
0664027	377223.33	412958.22	431589.31	-9.47	-14.41
0964053	435242.01	397901.05	417780.86	8.57	4.01
0964029	333587.87	373850.85	336235.31	-12.06	-.79
0964025	619832.57	687387.59	625217.25	-10.89	-.86
0964021	626081.34	689598.69	624219.07	-10.14	.29
0964017	433424.28	479205.76	444655.45	-10.56	-2.59
1164143	1058242.20	1177889.90	1077683.90	-11.30	-1.83
1264047	1361710.30	1493683.30	1345381.80	-9.69	1.19
1264051	735470.88	796078.83	730441.77	-8.24	.68
0465023	627698.32	594313.42	635546.09	5.31	-1.25
0665077	1187928.60	1245228.50	1182738.70	-4.82	.43
0665131	820689.39	702419.88	749715.97	14.41	8.64
0965007	867831.28	832514.12	868633.74	4.06	-.09
0166005	1142063.50	1317457.70	1184243.50	-15.35	-3.69
0266017	637246.00	695638.18	654685.40	-9.16	-2.73
0366031	592129.42	621632.55	570896.07	-4.98	3.58
0566041	501918.44	473147.15	485977.48	5.73	3.17
0766097	516877.28	558518.02	547707.34	-8.05	-5.96
0766107	193226.07	207783.83	215618.76	-7.53	-11.58
1266129	429210.66	431482.27	409161.89	-.52	4.67
1266111	477160.74	444042.83	523976.43	6.94	-9.81

REGRESSION II

ASPHALTIC CONCRETE PAVEMENT PROJECTS

PROJECT	LOW BID	ENG EST	REG EST	PRCNT DEVIATION EE	RE
0264035	1207121.90	1313944.20	1249001.70	-8.84	-3.46
0264023	352495.91	368792.94	354853.07	-4.62	-.66
0264029	1111918.50	1242730.70	1108310.50	-11.76	.32
0264017	500591.44	533163.15	504924.30	-6.50	-.86
0364005	181914.33	184056.22	182478.92	-1.17	-.31
0464015	1048058.90	1197934.00	1050810.50	-14.30	-.26
0464023	1466789.30	1583026.00	1438643.90	-7.92	1.91
0464071	105410.34	122630.94	92392.26	-16.33	12.34
0564053	233918.85	297389.88	243973.14	-27.13	-4.29
0564033	957869.33	1110232.10	966153.31	-15.90	-.86
0564037	1017401.40	1218567.60	1037529.80	-19.77	-1.97
0764011	1134814.60	1155743.80	1089795.20	-1.84	3.96
0864005	230034.79	277153.76	229976.44	-20.48	.02
0864137	285403.05	302905.85	300782.21	-6.13	-5.38
0864129	285806.93	290502.14	269222.11	-1.64	5.80
0864077	641346.21	670160.73	642795.83	-4.49	-.22
0864089	248715.53	277940.64	258430.98	-11.75	-3.90
0864083	248866.79	278597.76	248019.30	-11.94	.34
0964071	395771.43	423084.43	389358.11	-6.90	1.62
0964013	476782.47	503934.95	467976.22	-5.69	1.84
0964009	1304253.90	1404357.90	1314402.30	-7.67	-.77
0964005	210926.13	265778.19	227234.26	-26.00	-7.73
1264067	366978.72	457712.51	372453.00	-24.72	-1.49
0165029	439081.01	462225.49	436676.29	-5.27	.54
0365103	169166.60	167603.81	174746.38	.92	-3.29
0465079	610761.50	630347.99	597487.31	-3.20	2.17
0765127	430303.99	452351.66	432094.48	-5.12	-.41
0665087	253423.57	266143.38	240906.77	-5.01	4.93
0765083	51786.22	55071.41	50072.52	-6.34	3.30
1065059	333967.77	350378.21	317014.35	-4.91	5.07
0166043	738348.08	808884.53	751116.60	-9.55	-1.72
0266023	352281.11	391790.93	353745.26	-11.21	-.41
0366121	434447.46	472215.27	438761.73	-8.69	-.99
0366027	1357665.30	1397669.40	1362027.10	-2.94	-.32
0466033	494391.09	540022.06	484911.76	-9.22	1.91
0466041	376124.63	414738.86	376456.14	-10.26	-.08
0466037	493983.26	569514.03	497005.05	-15.29	-.61
0666115	163720.75	123258.37	147026.76	24.71	10.19
0666131	147280.88	138461.36	153330.53	5.98	-4.10
0666007	458302.60	440527.89	458423.31	3.87	-.02
0766101	185926.17	208130.99	198877.39	-11.94	-6.96
0766091	742766.84	828864.15	738192.48	-11.59	.61
0766063	646332.67	676007.15	631244.93	-4.59	2.33
0866121	97749.49	91545.19	111266.16	6.34	-13.82
0866117	153262.35	143332.45	168999.53	6.47	-10.26
1066019	239817.23	245345.09	230760.28	-2.30	3.77

REGRESSION III

P C CONCRETE PAVEMENT PROJECTS

PROJECT	LOW BID	ENG EST	REG EST	PRCNT DEVIATION EE	RE
0164013	715795.07	773726.01	735405.23	-8.09	-2.73
0164025	533601.52	567057.83	546905.81	-6.26	-2.49
0164045	667400.87	717788.01	674757.60	-7.54	-1.10
0264039	544858.00	525694.46	519695.96	3.51	4.61
0364013	997471.98	1120784.00	992608.81	-12.36	.48
0364019	403770.17	391177.77	415972.92	3.11	-3.02
0464019	473001.20	412958.22	414662.66	12.69	12.33
0664031	825856.88	871282.09	880259.78	-5.50	-6.58
0664019	799909.92	838516.10	782500.87	-4.82	2.17
0664015	1125759.60	1183435.60	1100839.10	-5.12	2.21
0664027	377223.33	412958.22	414662.66	-9.47	-9.92
0964053	435242.01	397901.05	446289.62	8.57	-2.53
0964029	333587.87	373850.85	383729.45	-12.06	-15.03
0964025	619832.57	687387.59	610299.02	-10.89	1.53
0964021	626081.34	689598.69	640881.82	-10.14	-2.36
0964017	433424.28	479205.76	412905.90	-10.56	4.73
1164143	1058242.20	1177889.90	1067197.90	-11.30	-.84
1264047	1361710.30	1493683.30	1359348.70	-9.69	.17
1264051	735470.88	796078.83	730716.23	-8.24	.64
0465023	627698.32	594313.42	613698.75	5.31	2.23
0665077	1187928.60	1245228.50	1179426.50	-4.82	.71
0665131	820689.39	702419.88	820501.14	14.41	.02
0965007	867831.28	832514.12	879127.59	4.06	-1.30
0166005	1142063.50	1317457.70	1151177.10	-15.35	-.79
0266017	637246.00	695638.18	616206.04	-9.16	3.30
0366031	592129.42	621632.55	562244.82	-4.98	5.04
0566041	501918.44	473147.15	505191.68	5.73	-.65
0766097	516877.28	558518.02	519175.43	-8.05	-.44
0766107	193226.07	207783.83	204409.26	-7.53	-5.78
1266129	429210.66	431482.27	432583.81	-.52	-.78
1266111	477160.74	444042.83	448834.87	6.94	5.93

REGRESSION III

ASPHALTIC CONCRETE PAVEMENT PROJECTS

PROJECT	LOW BID	ENG EST	REG EST	PRCNT DEVIATION EE	RE
0264035	1207121.90	1313944.20	1245012.90	-8.84	-3.13
0264023	352495.91	368792.94	325592.32	-4.62	7.63
0264029	1111918.50	1242730.70	1081814.10	-11.76	2.70
0264017	500591.44	533163.15	520178.42	-6.50	-3.91
0364005	181914.33	184056.22	188816.01	-1.17	-3.79
0464015	1048058.90	1197934.00	1094108.00	-14.30	-4.39
0464023	1466789.30	1583026.00	1429208.90	-7.92	2.56
0464071	105410.34	122630.94	112388.42	-16.33	-6.61
0564053	233918.85	297389.88	218523.61	-27.13	6.58
0564033	957869.33	1110232.10	991067.04	-15.90	-3.46
0564037	1017401.40	1218567.60	1015988.10	-19.77	.13
0764011	1134814.60	1155743.80	1086844.50	-1.84	4.22
0864005	230034.79	277153.76	281846.57	-20.48	-22.52
0864137	285403.05	302905.85	310087.25	-6.13	-8.64
0864129	285806.93	290502.14	285729.61	-1.64	.02
0864077	641346.21	670160.73	624251.03	-4.49	2.66
0864089	248715.53	277940.64	266788.82	-11.75	-7.26
0864083	248866.79	278597.76	246246.00	-11.94	1.05
0964071	395771.43	423084.43	366210.28	-6.90	7.46
0964013	476782.47	503934.95	512234.01	-5.69	-7.43
0964009	1304253.90	1404357.90	1298097.90	-7.67	.47
0964005	210926.13	265778.19	199201.60	-26.00	5.55
1264067	366978.72	457712.51	358312.35	-24.72	2.36
0165029	439081.01	462225.49	436493.01	-5.27	.58
0365103	169166.60	167603.81	200601.44	.92	-18.58
0465079	610761.50	630347.99	604887.93	-3.20	.96
0765127	430303.99	452351.66	388653.72	-5.12	9.67
0665087	253423.57	266143.38	266591.65	-5.01	-5.19
0765083	51786.22	55071.41	43643.12	-6.34	15.72
1065059	333967.77	350378.21	337823.02	-4.91	-1.15
0166043	738348.08	808884.53	737055.95	-9.55	.17
0266023	352281.11	391790.93	341474.12	-11.21	3.06
0366121	434447.46	472215.27	427880.23	-8.69	1.51
0366027	1357665.30	1397669.40	1361394.70	-2.94	-.27
0466033	494391.09	540022.06	525461.95	-9.22	-6.28
0466041	376124.63	414738.86	350058.60	-10.26	6.93
0466037	493983.26	569514.03	489484.88	-15.29	.91
0666115	163720.75	123258.37	157429.59	24.71	3.84
0666131	147280.88	138461.36	114375.03	5.98	22.34
0666007	458302.60	440527.89	488446.86	3.87	-6.57
0766101	185926.17	208130.99	184029.41	-11.94	1.02
0766091	742766.84	828864.15	722181.11	-11.59	2.77
0766063	646332.67	676007.15	658242.30	-4.59	-1.84
0866121	97749.49	91545.19	91235.87	6.34	6.66
0866117	153262.35	143332.45	157429.59	6.47	-2.71
1066019	239817.23	245345.09	259275.17	-2.30	-8.11

REGRESSION III

SECONDARY BITUMINOUS PAVEMENT PROJECTS

PROJECT	LOW BID	ENG EST	REG EST	PRCNT DEVIATION EE	RE
0264055	174271.70	191668.25	159041.90	-9.98	8.73
0364039	54311.77	59175.65	59259.74	-8.95	-9.11
0364113	39068.86	41394.67	23363.60	-5.95	40.19
0464063	44475.49	47929.05	46947.60	-7.76	-5.55
0464093	189071.53	234042.02	206609.02	-23.78	-9.27
0464097	162969.24	202005.82	162916.21	-23.95	.03
0564121	33002.44	35272.19	34503.24	-6.87	-4.54
0764065	67849.82	77889.58	74432.89	-14.79	-9.70
0864153	69857.79	71846.85	70987.74	-2.84	-1.61
0864167	21158.97	23144.46	38861.33	-9.38	-83.66
0864163	31153.34	34846.93	24628.54	-11.85	20.94
0864157	36883.52	39495.76	28743.42	-7.08	22.06
0864095	40126.77	42749.77	23506.40	-6.53	41.41
0864103	232332.30	280761.28	235677.96	-20.84	-1.44
0864141	182826.17	212961.13	166777.58	-16.48	8.77
0864145	142241.85	170711.75	139077.49	-20.01	2.22
0964037	225851.27	274717.88	218323.14	-21.63	3.33
0964041	203639.25	247087.32	203977.70	-21.33	-.16
0365091	48792.00	51412.37	50760.78	-5.37	-4.03
0465029	82634.09	96172.70	97781.38	-16.38	-18.33
0665107	73099.49	83105.26	52517.33	-13.68	28.15
0765139	74551.22	78222.40	86830.65	-4.92	-16.47
0765123	22876.68	24445.46	21124.36	-6.85	7.65
0965017	20966.08	19417.33	20920.17	7.38	.21
0166077	207653.94	244782.73	196115.96	-17.88	5.55
0466147	216646.68	257541.94	200977.22	-18.87	7.23
0566085	118906.06	149002.54	142208.55	-25.31	-19.59
0566081	110446.41	140140.64	109608.98	-26.88	.75
0566051	47256.16	47807.39	38598.42	-1.16	18.32
0566047	51750.36	52911.30	42755.54	-2.24	17.38
0566021	46285.24	47911.74	40935.99	-3.51	11.55
0566007	18028.74	18335.24	18985.61	-1.70	-5.30
0566011	34957.84	35419.76	30284.18	-1.32	13.36
0566003	34814.58	38064.22	42969.48	-9.33	-23.42
0666089	55077.50	63276.15	66212.06	-14.88	-20.21
0866139	104633.07	136380.57	118868.90	-30.34	-13.60
0866095	27243.11	29384.49	39952.81	-7.86	-46.65
0866091	37887.75	41870.93	49554.88	-10.51	-30.79

REGRESSION IV

ASPHALTIC CONCRETE PAVEMENT PROJECTS

PROJECT	LOW BID	ENG EST	REG EST	PRCNT DEVIATION EE	RE
0264035	1207121.90	1313944.20	1213127.00	-8.84	-.49
0264023	352495.91	368792.94	357843.08	-4.62	-1.51
0264029	1111918.50	1242730.70	1111507.40	-11.76	.03
0264017	500591.44	533163.15	499068.71	-6.50	.30
0364005	181914.33	184056.22	181773.67	-1.17	.07
0464015	1048058.90	1197934.00	1047423.10	-14.30	.06
0464023	1466789.30	1583026.00	1469821.40	-7.92	-.20
0464071	105410.34	122630.94	104021.10	-16.33	1.31
0564053	233918.85	297389.88	241988.24	-27.13	-3.44
0564033	957869.33	1110232.10	945557.77	-15.90	1.28
0564037	1017401.40	1218567.60	1025041.40	-19.77	-.75
0764011	1134814.60	1155743.80	1132891.10	-1.84	.16
0864005	230034.79	277153.76	238579.82	-20.48	-3.71
0864137	285403.05	302905.85	293663.49	-6.13	-2.89
0864129	285806.93	290502.14	278265.39	-1.64	2.63
0864077	641346.21	670160.73	638711.48	-4.49	.41
0864089	248715.53	277940.64	247722.19	-11.75	.39
0864083	248866.79	278597.76	259837.24	-11.94	-4.40
0964071	395771.43	423084.43	403001.08	-6.90	-1.82
0964013	476782.47	503934.95	458243.89	-5.69	3.88
0964009	1304253.90	1404357.90	1302522.50	-7.67	.13
0964005	210926.13	265778.19	220003.70	-26.00	-4.30
1264067	366978.72	457712.51	363826.32	-24.72	.85
0165029	439081.01	462225.49	443317.29	-5.27	-.96
0365103	169166.60	167603.81	169808.00	.92	-.37
0465079	610761.50	630347.99	609015.46	-3.20	.28
0765127	430303.99	452351.66	422636.45	-5.12	1.78
0665087	253423.57	266143.38	251902.11	-5.01	.60
0765083	51786.22	55071.41	53451.94	-6.34	-3.21
1065059	333967.77	350378.21	314848.05	-4.91	5.72
0166043	738348.08	808884.53	750287.67	-9.55	-1.61
0266023	352281.11	391790.93	362783.23	-11.21	-2.98
0366121	434447.46	472215.27	435068.12	-8.69	-.14
0366027	1357665.30	1397669.40	1354608.40	-2.94	.22
0466033	494391.09	540022.06	498325.47	-9.22	-.79
0466041	376124.63	414738.86	374852.36	-10.26	.33
0466037	493983.26	569514.03	510043.34	-15.29	-3.25
0666115	163720.75	123258.37	152381.85	24.71	6.92
0666131	147280.88	138461.36	127409.25	5.98	13.49
0666007	458302.60	440527.89	456011.04	3.87	.50
0766101	185926.17	208130.99	191671.40	-11.94	-3.09
0766091	742766.84	828864.15	736898.10	-11.59	.79
0766063	646332.67	676007.15	633851.28	-4.59	1.93
0866121	97749.49	91545.19	100781.34	6.34	-3.10
0866117	153262.35	143332.45	169322.53	6.47	-10.47
1066019	239817.23	245345.09	239859.38	-2.30	-.01

REGRESSION V

ASPHALTIC CONCRETE PAVEMENT PROJECTS
BLACK BASE

PROJECT	LOW BID	ENG EST	REG EST	PRCNT DEVIATION EE	RE
0264035	1207121.90	1313944.00	1228918.10	-8.84	-1.80
0264023	352495.91	368793.00	350380.02	-4.62	.60
0264029	1111918.50	1242731.00	1117946.20	-11.76	-.54
0264017	500591.44	533163.00	485983.17	-6.50	2.91
0364005	181914.33	184056.22	201953.68	-1.17	-11.01
0464015	1048058.90	1197934.00	1059447.60	-14.30	-1.08
0464023	1466789.30	1583026.00	1448164.60	-7.92	1.26
0464071	105410.34	122631.00	91000.65	-16.33	13.67
0564033	957869.33	1110232.00	968402.70	-15.90	-1.09
0564037	1017401.40	1218568.00	1013880.10	-19.77	.34
0764011	1134814.60	1155743.00	1106914.30	-1.84	2.45
0864089	248715.53	277940.00	267897.60	-11.75	-7.71
0864083	248866.79	278598.00	252036.96	-11.94	-1.27
0964071	395771.43	423064.00	401046.29	-6.89	-1.33
0964013	476782.47	503935.00	464741.16	-5.69	2.52
0964009	1304253.90	1404357.00	1309673.80	-7.67	-.41
0964005	210926.13	265778.00	219894.82	-26.00	-4.25
1264067	366978.72	457712.00	366620.83	-24.72	.09
0665087	253423.57	266143.00	253917.75	-5.01	-.19

REGRESSION V

ASPHALTIC CONCRETE PAVEMENT PROJECTS
SAND BASE

PROJECT	LOW BID	ENG EST	REG EST	PRCNT DEVIATION EE	RE
0864137	285403.05	302906.00	286366.94	-6.13	-.33
0864129	285806.93	290502.00	275996.80	-1.64	3.43
0864077	641346.21	670161.00	645686.21	-4.49	-.67
0165029	439081.01	462225.00	446923.86	-5.27	-1.78
0465079	610761.50	630348.00	610381.15	-3.20	.06
0765127	430303.99	452351.00	440998.20	-5.12	-2.48
0765083	51786.22	55071.00	57328.46	-6.34	-10.70
1065059	333967.77	350378.00	342555.26	-4.91	-2.57
0166043	738348.08	808884.00	737572.09	-9.55	.10
0266023	352281.11	391790.00	355507.68	-11.21	-.91
0366121	434447.46	472215.00	427477.17	-8.69	1.60
0366027	1357665.30	1397669.00	1356499.50	-2.94	.08
0466033	494391.09	540022.00	476856.56	-9.22	3.54
0466041	376124.63	414738.00	383070.54	-10.26	-1.84
0466037	493983.26	569514.00	499369.12	-15.29	-1.09
0666131	147280.88	138461.00	134105.54	5.98	8.94
0666007	458302.60	440527.00	439866.45	3.87	4.02
0766101	185926.17	208131.00	197875.02	-11.94	-6.42
0766091	742766.84	828864.00	752457.30	-11.59	-1.30
0766063	646332.67	676007.00	639379.09	-4.59	1.07

APPENDIX D

EXPECTED PROFIT FROM BIDS FOR EMPIRICAL DISTRIBUTION

EXPECTED RETURNS

BID PRCNT	PROB	COST PERCENT 84	85	86	87	88
84	.970	0.000				
85	.968	.968	0.000			
86	.966	1.932	.966	0.000		
87	.964	2.892	1.928	.964	0.000	
88	.962	3.848	2.886	1.924	.962	0.000
89	.960	4.800	3.840	2.880	1.920	.960
90	.958	5.748	4.790	3.832	2.874	1.916
91	.956	6.692	5.736	4.780	3.824	2.868
92	.954	7.632	6.678	5.724	4.770	3.816
93	.952	8.568	7.616	6.664	5.712	4.760
94	.950	9.500	8.550	7.600	6.650	5.700
95	.940	10.340	9.400	8.460	7.520	6.580
96	.930	11.160	10.230	9.300	8.370	7.440
97	.920	11.960	11.040	10.120	9.200	8.280
98	.880	12.320	11.440	10.560	9.680	8.800
99	.820	12.300	11.480	10.660	9.840	9.020
100	.440	7.040	6.600	6.160	5.720	5.280
101	.290	4.930	4.640	4.350	4.060	3.770
102	.200	3.600	3.400	3.200	3.000	2.800
103	.130	2.470	2.340	2.210	2.080	1.950
104	.070	1.400	1.330	1.260	1.190	1.120

BID PRCNT	PROB	COST PERCENT 89	90	91	92	93
89	.960	0.000				
90	.958	.958	0.000			
91	.956	1.912	.956	0.000		
92	.954	2.862	1.908	.954	0.000	
93	.952	3.808	2.856	1.904	.952	0.000
94	.950	4.750	3.800	2.850	1.900	.950
95	.940	5.640	4.700	3.760	2.820	1.880
96	.930	6.510	5.580	4.650	3.720	2.790
97	.920	7.360	6.440	5.520	4.600	3.680
98	.880	7.920	7.040	6.160	5.280	4.400
99	.820	8.200	7.380	6.560	5.740	4.920
100	.440	4.840	4.400	3.960	3.520	3.080
101	.290	3.480	3.190	2.900	2.610	2.320
102	.200	2.600	2.400	2.200	2.000	1.800
103	.130	1.820	1.690	1.560	1.430	1.300
104	.070	1.050	.980	.910	.840	.770

EXPECTED RETURNS

BID PRCNT	PROB	COST PERCENT 94	95	96	97	98
94	.950	0.000				
95	.940	.940	0.000			
96	.930	1.860	.930	0.000		
97	.920	2.760	1.840	.920	0.000	
98	.880	3.520	2.640	1.760	.880	0.000
99	.820	4.100	3.280	2.460	1.640	.820
100	.440	2.640	2.200	1.760	1.320	.880
101	.290	2.030	1.740	1.450	1.160	.870
102	.200	1.600	1.400	1.200	1.000	.800
103	.130	1.170	1.040	.910	.780	.650
104	.070	.700	.630	.560	.490	.420

BID PRCNT	PROB	COST PERCENT 99	100	101	102	103
99	.820	0.000				
100	.440	.440	0.000			
101	.290	.580	.290	0.000		
102	.200	.600	.400	.200	0.000	
103	.130	.520	.390	.260	.130	0.000
104	.070	.350	.280	.210	.140	.070

VITA

Larry Ray Johnson

Candidate for the Degree of

Doctor of Philosophy

Thesis: A COMPETITIVE STRATEGY MODEL FOR HIGHWAY CONSTRUCTION PROPOSALS

Major Field: Engineering

Biographical:

Personal Data: Born in Atlanta, Georgia, December 18, 1935, the son of Lawrence V. and Cecelia Johnson.

Education: Graduated from North Fulton High School, Atlanta, Georgia, in May, 1954; received the Bachelor of Ceramic Engineering degree from Georgia Institute of Technology, Atlanta, Georgia, in May, 1958; received the Bachelor of Industrial Engineering degree from Georgia Institute of Technology, Atlanta, Georgia, in May, 1960; received the Master of Science degree in Industrial Engineering from Georgia Institute of Technology, Atlanta, Georgia, in May, 1962; completed requirements for the Doctor of Philosophy degree in May, 1969.

Professional Experience: Employed by the Lockheed-Georgia Company from April, 1961, to September, 1963, as an Associate Manufacturing Research Engineer; employed by Mississippi State University from September, 1963, to January, 1969, as an Assistant Professor in Industrial Engineering, and from January, 1969, to present, as an Associate Professor in Industrial Engineering.

Professional Membership: Registered Professional Engineer, Georgia and Mississippi; Keramos; Alpha Pi Mu; American Institute of Industrial Engineers.